This document, concerning Consumer Water Heaters is an action issued by the Department of Energy. Though it is not intended or expected, should any discrepancy occur between the document posted here and the document published in the Federal Register, the Federal Register publication controls. This document is being made available through the Internet solely as a means to facilitate the public's access to this document. Pursuant to 10 CFR 430.5(c)(1), the Secretary has not made this rule available to review for errors in the document's regulatory text.

[6450-01-P]

DEPARTMENT OF ENERGY

10 CFR Parts 429 and 430

[EERE 2017-BT-STD-0019]

RIN 1904-AD91

Energy Conservation Program: Energy Conservation Standards for Consumer Water Heaters

AGENCY: Office of Energy Efficiency and Renewable Energy, Department of Energy.

ACTION: Final rule.

SUMMARY: The Energy Policy and Conservation Act, as amended ("EPCA"), prescribes energy conservation standards for various consumer products and certain commercial and industrial equipment, including consumer water heaters**.** EPCA also requires the U.S. Department of Energy ("DOE" or "the Department") to periodically determine whether more stringent standards would be technologically feasible and economically justified, and would result in significant energy savings. In this final rule, DOE is adopting amended energy conservation standards for consumer water heaters. It has determined that the new and amended energy conservation standards for these products would result in significant conservation of energy, and are technologically feasible and economically justified.

DATES: The effective date of this rule is **[INSERT DATE 60 DAYS AFTER DATE OF PUBLICATION IN THE *FEDERAL REGISTER*]**. Compliance with the new and amended standards established for consumer water heaters in this final rule is required on and after **[INSERT DATE 5 YRS AFTER DATE OF PUBLICATION]**.

ADDRESSES: The docket for this rulemaking, which includes *Federal Register* notices, public meeting attendee lists and transcripts, comments, and other supporting documents/materials, is available for review at *www.regulations.gov*. All documents in the docket are listed in the *www.regulations.gov* index. However, not all documents listed in the index may be publicly available, such as information that is exempt from public disclosure.

The docket webpage can be found at *www.regulations.gov/docket/EERE-2017-BT-STD-0019*. The docket webpage contains instructions on how to access all documents, including public comments, in the docket.

FOR FURTHER INFORMATION CONTACT:

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For further information on how to review the docket, contact the Appliance and Equipment Standards Program staff at (202) 287-1445 or by email: *ApplianceStandardsQuestions@ee.doe.gov*.

SUPPLEMENTARY INFORMATION:

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I. Synopsis of the Final Rule

The Energy Policy and Conservation Act, Pub. L. 94-163, as amended ("EPCA"),[1] authorizes DOE to regulate the energy efficiency of a number of consumer products and certain industrial equipment. (42 U.S.C. 6291–6317) Title III, Part B of EPCA[2] established the Energy Conservation Program for Consumer Products Other Than Automobiles. (42 U.S.C. 6291-6309) These products include consumer water heaters, the subject of this rulemaking. As discussed in section II.B.3, DOE is finalizing standards for all consumer water heaters, with the exception of gas-fired instantaneous water heaters, in this Final Rule.

Pursuant to EPCA, any new or amended energy conservation standard must be designed to achieve the maximum improvement in energy efficiency that DOE determines is technologically feasible and economically justified. (42 U.S.C. 6295(o)(2)(A)) Furthermore, the new or amended standard must result in significant conservation of energy. (42 U.S.C. 6295(o)(3)(B)) EPCA also provides that not later than 6 years after issuance of any final rule establishing or amending a standard, DOE must publish either a notice of determination that standards for the product do not need to be amended, or a notice of proposed rulemaking including new proposed energy conservation standards (proceeding to a final rule, as appropriate). (42 U.S.C. 6295(m))

In accordance with these and other statutory provisions discussed in this document, DOE analyzed the benefits and burdens of six trial standard levels ("TSLs")

[1] All references to EPCA in this document refer to the statute as amended through the Energy Act of 2020, Pub. L. 116-260 (Dec. 27, 2020), which reflect the last statutory amendments that impact Parts A and A-1 of EPCA.
[2] For editorial reasons, upon codification in the U.S. Code, Part B was redesignated Part A.

for consumer water heaters. The TSLs and their associated benefits and burdens are discussed in detail in sections V.A through V.C of this document. As discussed in section V.C of this document, DOE has determined that TSL 2 represents the maximum improvement in energy efficiency that is technologically feasible and economically justified. The adopted standards, which are expressed in terms of uniform energy factor ("UEF"), are shown in Table I.1. These standards apply to all products listed in Table I.1 and manufactured in, or imported into, the United States starting on **[INSERT DATE 5 YEARS AFTER DATE OF FEDERAL REGISTER PUBLICATION]**.

Table I.1 Energy Conservation Standards for Consumer Water Heaters (Compliance Starting [INSERT DATE 5 YEARS AFTER DATE OF FEDERAL REGISTER PUBLICATION])

Product Class	Effective Storage Volume and Input Rating *(if applicable)*	Draw Pattern	Uniform Energy Factor*
Gas-fired Storage Water Heater	< 20 gal	Very Small	$0.2062 - (0.0020 \times V_{eff})$
		Low	$0.4893 - (0.0027 \times V_{eff})$
		Medium	$0.5758 - (0.0023 \times V_{eff})$
		High	$0.6586 - (0.0020 \times V_{eff})$
	≥ 20 gal and ≤ 55 gal	Very Small	$0.3925 - (0.0020 \times V_{eff})$
		Low	$0.6451 - (0.0019 \times V_{eff})$
		Medium	$0.7046 - (0.0017 \times V_{eff})$
		High	$0.7424 - (0.0013 \times V_{eff})$
	>55 gal and ≤ 100 gal	Very Small	$0.6470 - (0.0006 \times V_{eff})$
		Low	$0.7689 - (0.0005 \times V_{eff})$
		Medium	$0.7897 - (0.0004 \times V_{eff})$
		High	$0.8072 - (0.0003 \times V_{eff})$
	> 100 gal	Very Small	$0.1482 - (0.0007 \times V_{eff})$
		Low	$0.4342 - (0.0017 \times V_{eff})$
		Medium	$0.5596 - (0.0020 \times V_{eff})$
		High	$0.6658 - (0.0019 \times V_{eff})$
Oil-fired Storage Water Heater	≤ 50 gal	Very Small	$0.2909 - (0.0012 \times V_{eff})$
		Low	$0.5730 - (0.0016 \times V_{eff})$
		Medium	$0.6478 - (0.0016 \times V_{eff})$
		High	$0.7215 - (0.0014 \times V_{eff})$
	> 50 gal	Very Small	$0.1580 - (0.0009 \times V_{eff})$
		Low	$0.4390 - (0.0020 \times V_{eff})$
		Medium	$0.5389 - (0.0021 \times V_{eff})$
		High	$0.6172 - (0.0018 \times V_{eff})$
Very Small Electric Storage Water Heater	< 20 gal	Very Small	$0.5925 - (0.0059 \times V_{eff})$
		Low	$0.8642 - (0.0030 \times V_{eff})$
		Medium	$0.9096 - (0.0020 \times V_{eff})$

		High	$0.9430 - (0.0012 \times V_{eff})$
Small Electric Storage Water Heater	≥ 20 gal and ≤ 35 gal	Very Small	$0.8808 - (0.0008 \times V_{eff})$
		Low	$0.9254 - (0.0003 \times V_{eff})$
Electric Storage Water Heaters	> 20 and ≤ 55 gal (excluding small electric storage water heaters)	Very Small	2.30
		Low	2.30
		Medium	2.30
		High	2.30
	> 55 gal and ≤120 gal	Very Small	2.50
		Low	2.50
		Medium	2.50
		High	2.50
	> 120 gal	Very Small	$0.3574 - (0.0012 \times V_{eff})$
		Low	$0.7897 - (0.0019 \times V_{eff})$
		Medium	$0.8884 - (0.0017 \times V_{eff})$
		High	$0.9575 - (0.0013 \times V_{eff})$
Tabletop Water Heater	< 20 gal	Very Small	$0.5925 - (0.0059 \times V_{eff})$
		Low	$0.8642 - (0.0030 \times V_{eff})$
	≥ 20 gal	Very Small	$0.6323 - (0.0058 \times V_{eff})$
		Low	$0.9188 - (0.0031 \times V_{eff})$
Instantaneous Gas-fired Water Heater**	<2 gal and >50,000 Btu/h	Very Small	0.80
		Low	0.81
		Medium	0.81
		High	0.81
Instantaneous Oil-fired Water Heater	< 2 gal and ≤ 210,000 Btu/h	Very Small	0.61
		Low	0.61
		Medium	0.61
		High	0.61
	≥ 2 gal and ≤ 210,000 Btu/h	Very Small	$0.2780 - (0.0022 \times V_{eff})$
		Low	$0.5151 - (0.0023 \times V_{eff})$
		Medium	$0.5687 - (0.0021 \times V_{eff})$
		High	$0.6147 - (0.0017 \times V_{eff})$
Instantaneous Electric Water Heater	< 2 gal	Very Small	0.91
		Low	0.91
		Medium	0.91
		High	0.92
	≥ 2 gal	Very Small	$0.8086 - (0.0050 \times V_{eff})$
		Low	$0.9123 - (0.0020 \times V_{eff})$
		Medium	$0.9252 - (0.0015 \times V_{eff})$
		High	$0.9350 - (0.0011 \times V_{eff})$
Grid-Enabled Water Heater	> 75 gal	Very Small	$1.0136 - (0.0028 \times V_{eff})$
		Low	$0.9984 - (0.0014 \times V_{eff})$
		Medium	$0.9853 - (0.0010 \times V_{eff})$
		High	$0.9720 - (0.0007 \times V_{eff})$

* V_{eff} is the Effective Storage Volume (in gallons), as determined pursuant to 10 CFR 429.17.

** As discussed in section II.B.3 of this document, DOE is still considering amended energy conservation standards for gas-fired instantaneous water heaters.

A. Benefits and Costs to Consumers

Table I.2 summarizes DOE's evaluation of the economic impacts of the adopted standards on consumers of consumer water heaters, as measured by the average life-cycle cost ("LCC") savings and the simple payback period ("PBP").[3] The average LCC savings are positive for all product classes, and the PBP is less than the average lifetime of consumer water heaters, which is estimated to be about 15 years for storage water heaters (*see* section IV.F of this document).

Table I.2 Impacts of Adopted Energy Conservation Standards on Consumers of Consumer Water Heaters

Product Class	Effective Storage Volume and Input Rating	Average LCC Savings	Simple Payback
	(if applicable)	*2022$*	*years*
Gas-fired Storage Water Heater	≥20 gal and ≤55 gal	29	9.1
Oil-fired Storage Water Heater	≤50 gal	141	6.5
Electric Storage Water Heaters	Small Electric Storage Water Heaters ≥20 gal and ≤35 gal (<51 gal FHR)	N/A	N/A
	≥20 gal and ≤55 gal, Excluding Small Electric Storage Water Heaters	859	5.6
	>55 gal and ≤120 gal	458	0.2

DOE's analysis of the impacts of the adopted standards on consumers is described in section IV.F of this document.

[3] The average LCC savings refer to consumers that are affected by a standard and are measured relative to the efficiency distribution in the no-new-standards case, which depicts the market in the compliance year in the absence of new or amended standards (*see* section IV.F.9 of this document). The simple PBP, which is designed to compare specific efficiency levels, is measured relative to the baseline product (*see* section IV.C of this document).

B. Impact on Manufacturers

The industry net present value ("INPV") is the sum of the discounted cash flows to the industry from the base year through the end of the analysis period (2023–2059). Using a real discount rate of 9.6 percent, DOE estimates that the INPV for manufacturers of consumer water heaters in the case without amended standards is $1,478.8 million in 2022$. Under the adopted standards, DOE estimates the change in INPV to range from -18.6 percent to 1.9 percent, which is a loss of $275.3 million to a gain of $28.2 million. In order to bring products into compliance with amended standards, it is estimated that industry will incur total conversion costs of $239.8 million.

DOE's analysis of the impacts of the adopted standards on manufacturers is described in section IV.J and section V.B.2 of this document.

C. National Benefits and Costs[4]

DOE's analyses indicate that the adopted energy conservation standards for consumer water heaters would save a significant amount of energy. Relative to the case without amended standards, the lifetime energy savings for consumer water heaters purchased in the 30-year period that begins in the anticipated year of compliance with the amended standards (2030–2059), amount to 17.6 quadrillion British thermal units ("Btu"), or quads.[5] This represents a savings of 10 percent relative to the energy use of

[4] All monetary values in this document are expressed in 2022 dollars.
[5] The quantity refers to full-fuel-cycle (FFC) energy savings. FFC energy savings includes the energy consumed in extracting, processing, and transporting primary fuels (*i.e.*, coal, natural gas, petroleum fuels), and, thus, presents a more complete picture of the impacts of energy efficiency standards. For more information on the FFC metric, *see* section IV.H.1 of this document.

these products in the case without amended standards (referred to as the “no-new-standards case”).

The cumulative net present value (“NPV”) of total consumer benefits of the standards for consumer water heaters ranges from $25 billion (at a 7-percent discount rate) to $82 billion (at a 3-percent discount rate). This NPV expresses the estimated total value of future operating-cost savings minus the estimated increased product and installation costs for consumer water heaters purchased during the period 2030–2059.

In addition, the adopted standards for consumer water heaters are projected to yield significant environmental benefits. DOE estimates that the standards will result in cumulative emission reductions (over the same period as for energy savings) of 332 million metric tons (“Mt”)[6] of carbon dioxide (“CO_2”), 90 thousand tons of sulfur dioxide (“SO_2”), 665 thousand tons of nitrogen oxides (“NO_X”), 3,058 thousand tons of methane (“CH_4”), 2.9 thousand tons of nitrous oxide (“N_2O”), and 0.6 tons of mercury (“Hg”).[7]

DOE estimates the value of climate benefits from a reduction in greenhouse gases (“GHG”) using four different estimates of the social cost of CO_2 (“SC-CO_2”), the social cost of methane (“SC-CH_4”), and the social cost of nitrous oxide (“SC-N_2O”). Together these represent the social cost of GHG (“SC-GHG”). DOE used interim SC-GHG values (in terms of benefit per ton of GHG avoided) developed by an Interagency Working

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[6] A metric ton is equivalent to 1.1 short tons. Results for emissions other than CO_2 are presented in short tons.

[7] DOE calculated emissions reductions relative to the no-new-standards-case, which reflects key assumptions in the *Annual Energy Outlook 2023* (*“AEO2023”*). *AEO2023* reflects, to the extent possible, laws and regulations adopted through mid-November 2022, including the Inflation Reduction Act. *See* section IV.K of this document for further discussion of *AEO2023* assumptions that affect air pollutant emissions.

Group on the Social Cost of Greenhouse Gases ("IWG").[8] The derivation of these values is discussed in section IV.L of this document. For presentational purposes, the climate benefits associated with the average SC-GHG at a 3-percent discount rate are estimated to be $17 billion. DOE does not have a single central SC-GHG point estimate and it emphasizes the value of considering the benefits calculated using all four sets of SC-GHG estimates. DOE notes, however, that the adopted standards would be economically justified even without inclusion of monetized benefits of reduced GHG emissions.

DOE estimated the monetary health benefits of SO_2 and NO_X emissions reductions, using benefit per ton estimates from the Environmental Protection Agency,[9] as discussed in section IV.L of this document. DOE estimated the present value of the health benefits would be $12 billion using a 7-percent discount rate, and $33 billion using a 3-percent discount rate.[10] DOE is currently only monetizing health benefits from changes in ambient fine particulate matter ($PM_{2.5}$) concentrations from two precursors (SO_2 and NO_X), and from changes in ambient ozone from one precursor (for NO_X), but will continue to assess the ability to monetize other effects such as health benefits from reductions in direct $PM_{2.5}$ emissions.

[8] To monetize the benefits of reducing GHG emissions this analysis uses the interim estimates presented in the *Technical Support Document: Social Cost of Carbon, Methane, and Nitrous Oxide Interim Estimates Under Executive Order 13990* published in February 2021 by the IWG. ("February 2021 SC-GHG TSD"). *www.whitehouse.gov/wp-content/uploads/2021/02/TechnicalSupportDocument_SocialCostofCarbonMethaneNitrousOxide.pdf.*
[9] U.S. EPA. Estimating the Benefit per Ton of Reducing Directly Emitted PM2.5, PM2.5 Precursors and Ozone Precursors from 21 Sectors. Available at *www.epa.gov/benmap/estimating-benefit-ton-reducing-pm25-precursors-21-sectors.*
[10] DOE estimates the economic value of these emissions reductions resulting from the considered TSLs for the purpose of complying with the requirements of Executive Order 12866.

Table I.3 summarizes the monetized benefits and costs expected to result from the amended standards for consumer water heaters. There are other important unquantified effects, including certain unquantified climate benefits, unquantified public health benefits from the reduction of toxic air pollutants and other emissions, unquantified energy security benefits, and distributional effects, among others.

Table I.3 Summary of Monetized Benefits and Costs of Adopted Energy Conservation Standards for Consumer Water Heaters

	Billion $2022
3% discount rate	
Consumer Operating Cost Savings	124
Climate Benefits*	17
Health Benefits**	33
Total Benefits†	175
Consumer Incremental Product Costs‡	42
Net Benefits	132
Change in Producer Cashflow (INPV)‡‡	(0.28) - 0.03
7% discount rate	
Consumer Operating Cost Savings	47
Climate Benefits* (3% discount rate)	17
Health Benefits**	12
Total Benefits†	76
Consumer Incremental Product Costs‡	22
Net Benefits	54
Change in Producer Cashflow (INPV)‡‡	(0.28) - 0.03

Note: This table presents the costs and benefits associated with consumer water heaters shipped during the period 2030−2059. These results include consumer, climate, and health benefits that accrue after 2059 from the products shipped during the period 2030−2059.
* Climate benefits are calculated using four different estimates of the social cost of carbon ($SC-CO_2$), methane ($SC-CH_4$), and nitrous oxide ($SC-N_2O$) (model average at 2.5 percent, 3 percent, and 5 percent discount rates; 95th percentile at 3 percent discount rate) (see section IV.L of this notice). Together these represent the global SC-GHG. For presentational purposes of this table, the climate benefits associated with the average SC-GHG at a 3 percent discount rate are shown; however, DOE emphasizes the value of

considering the benefits calculated using all four sets of SC-GHG estimates. To monetize the benefits of reducing GHG emissions, this analysis uses the interim estimates presented in the *Technical Support Document: Social Cost of Carbon, Methane, and Nitrous Oxide Interim Estimates Under Executive Order 13990* published in February 2021 by the IWG.
** Health benefits are calculated using benefit-per-ton values for NO_X and SO_2. DOE is currently only monetizing (for SO_2 and NO_X) $PM_{2.5}$ precursor health benefits and (for NO_X) ozone precursor health benefits, but will continue to assess the ability to monetize other effects such as health benefits from reductions in direct $PM_{2.5}$ emissions. See section IV.L of this document for more details.
† Total and net benefits include those consumer, climate, and health benefits that can be quantified and monetized. For presentation purposes, total and net benefits for both the 3-percent and 7-percent cases are presented using the average SC-GHG with 3-percent discount rate.
‡ Costs include incremental equipment costs as well as installation costs.
‡‡ Operating Cost Savings are calculated based on the life cycle costs analysis and national impact analysis as discussed in detail below. *See* sections IV.F and IV.H of this document. DOE's national impacts analysis includes all impacts (both costs and benefits) along the distribution chain beginning with the increased costs to the manufacturer to manufacture the product and ending with the increase in price experienced by the consumer. DOE also separately conducts a detailed analysis on the impacts on manufacturers (*i.e.*, manufacturer impact analysis, or "MIA"). *See* section IV.J of this document. In the detailed MIA, DOE models manufacturers' pricing decisions based on assumptions regarding investments, conversion costs, cashflow, and margins. The MIA produces a range of impacts, which is the rule's expected impact on the INPV. The change in INPV is the present value of all changes in industry cash flow, including changes in production costs, capital expenditures, and manufacturer profit margins. Change in INPV is calculated using the industry weighted average cost of capital value of 9.6 percent that is estimated in the manufacturer impact analysis (*see* chapter 12 of the final rule technical support document ("TSD") for a complete description of the industry weighted average cost of capital). For consumer water heaters, the change in INPV ranges from -$275 million to $28 million. DOE accounts for that range of likely impacts in analyzing whether a trial standard level is economically justified. *See* section V.C of this document. DOE is presenting the range of impacts to the INPV under two scenarios: the Preservation of Gross Margin scenario, which is the manufacturer markup scenario used in the calculation of Consumer Operating Cost Savings in this table; and the Preservation of Operating Profit scenario, where DOE assumed manufacturers would not be able to increase per-unit operating profit in proportion to increases in manufacturer production costs. DOE includes the range of estimated INPV in the above table, drawing on the MIA explained further in section IV.J of this document to provide additional context for assessing the estimated impacts of this final rule to society, including potential changes in production and consumption, which is consistent with OMB's Circular A-4 and E.O. 12866. If DOE were to include the INPV into the net benefit calculation for this final rule, the net benefits would range from $131.7 billion to $132.0 billion at 3-percent discount rate and would range from $53.7 billion to $54.0 billion at 7-percent discount rate.

The benefits and costs of the proposed standards can also be expressed in terms of annualized values. The monetary values for the total annualized net benefits are (1) the reduced consumer operating costs, minus (2) the increase in product purchase prices and installation costs, plus (3) the value of climate and health benefits of emission reductions, all annualized.[11]

The national operating cost savings are domestic private U.S. consumer monetary savings that occur as a result of purchasing the covered products and are measured for the lifetime of consumer water heaters shipped during the period 2030–2059. The benefits associated with reduced emissions achieved as a result of the adopted standards are also calculated based on the lifetime of consumer water heaters shipped during the period 2030–2059. Total benefits for both the 3-percent and 7-percent cases are presented using the average GHG social costs with 3-percent discount rate. Estimates of total benefits are presented for all four SC-GHG value discount rates in section IV.L.1 of this document.

Table I.4 presents the total estimated monetized benefits and costs associated with the proposed standard, expressed in terms of annualized values. The results under the primary estimate are as follows.

Using a 7-percent discount rate for consumer benefits and costs and health benefits from reduced NO_X and SO_2 emissions, and the 3-percent discount rate case for climate benefits from reduced GHG emissions, the estimated cost of the standards adopted in this rule is $2,623 million per year in increased equipment costs, while the estimated annual benefits are $5,655 million in reduced equipment operating costs,

[11] To convert the time-series of costs and benefits into annualized values, DOE calculated a present value in 2022, the year used for discounting the NPV of total consumer costs and savings. For the benefits, DOE calculated a present value associated with each year's shipments in the year in which the shipments occur (*e.g.*, 2020 or 2030), and then discounted the present value from each year to 2022. Using the present value, DOE then calculated the fixed annual payment over a 30-year period, starting in the compliance year, that yields the same present value.

$1,051 in monetized climate benefits, and 1,416 in monetized health benefits. In this case, the net benefit would amount to $5,499 per year.

Using a 3-percent discount rate for all benefits and costs, the estimated cost of the standards is $2,586 million per year in increased equipment costs, while the estimated annual benefits are $7,566 million in reduced operating costs, $1,051 million in monetized climate benefits, and $2,033 million in monetized health benefits. In this case, the net benefit would amount to $8,065 million per year.

Table I.4 Annualized Benefits and Costs of Adopted Standards for Consumer Water Heaters

	Million 2022$/year		
	Primary Estimate	**Low-Net-Benefits Estimate**	**High-Net-Benefits Estimate**
	3% discount rate		
Consumer Operating Cost Savings	7,566	7,078	8,065
Climate Benefits*	1,051	1,039	1,063
Health Benefits**	2,033	2,009	2,058
Total Benefits†	10,650	10,125	11,186
Consumer Incremental Product Costs‡	2,586	3,023	2,398
Net Benefits	8,065	7,102	8,788
Change in Producer Cashflow (INPV)‡‡	(28) - 3	(28) - 3	(28) - 3
	7% discount rate		
Consumer Operating Cost Savings	5,655	5,294	6,024
Climate Benefits* (3% discount rate)	1,051	1,039	1,063
Health Benefits**	1,416	1,400	1,432
Total Benefits†	8,122	7,732	8,519
Consumer Incremental Product Costs‡	2,623	2,984	2,467
Net Benefits	5,499	4,748	6,052
Change in Producer Cashflow (INPV)‡‡	(28) - 3	(28) - 3	(28) - 3

Note: This table presents the costs and benefits associated with consumer water heaters shipped during the period 2030−2059. These results include consumer, climate, and health benefits that accrue after 2059 from the products shipped during the period 2030−2059. The Primary, Low Net Benefits, and High Net Benefits Estimates utilize projections of energy prices from the *AEO2023* Reference case, Low Economic Growth case, and High Economic Growth case, respectively. In addition, incremental equipment costs reflect a medium decline rate in the Primary Estimate, a low decline rate in the Low Net Benefits Estimate, and a high decline rate in the High Net Benefits Estimate. The methods used to derive projected price trends are explained in sections IV.F.1 and IV.F.4 of this document. Note that the Benefits and Costs may not sum to the Net Benefits due to rounding.

* Climate benefits are calculated using four different estimates of the global SC-GHG (see section IV.L of this notice). For presentational purposes of this table, the climate benefits associated with the average SC-GHG at a 3 percent discount rate are shown; however, DOE emphasizes the value of considering the benefits calculated using all four sets of SC-GHG estimates. To monetize the benefits of reducing GHG emissions, this analysis uses the interim estimates presented in the *Technical Support Document: Social Cost of Carbon, Methane, and Nitrous Oxide Interim Estimates Under Executive Order 13990* published in February 2021 by the IWG.

** Health benefits are calculated using benefit-per-ton values for NO_X and SO_2. DOE is currently only monetizing (for SO_2 and NO_X) $PM_{2.5}$ precursor health benefits and (for NO_X) ozone precursor health benefits, but will continue to assess the ability to monetize other effects such as health benefits from reductions in direct $PM_{2.5}$ emissions. *See* section IV.L of this document for more details.

† Total benefits for both the 3-percent and 7-percent cases are presented using the average SC-GHG with 3-percent discount rate.
‡ Costs include incremental equipment costs as well as installation costs.
‡‡ Operating Cost Savings are calculated based on the life cycle costs analysis and national impact analysis as discussed in detail below. *See* sections IV.F and IV.H of this document. DOE's national impacts analysis includes all impacts (both costs and benefits) along the distribution chain beginning with the increased costs to the manufacturer to manufacture the product and ending with the increase in price experienced by the consumer. DOE also separately conducts a detailed analysis on the impacts on manufacturers (*i.e.*, manufacturer impact analysis, or "MIA"). *See* section IV.J of this document. In the detailed MIA, DOE models manufacturers' pricing decisions based on assumptions regarding investments, conversion costs, cashflow, and margins. The MIA produces a range of impacts, which is the rule's expected impact on the INPV. The change in INPV is the present value of all changes in industry cash flow, including changes in production costs, capital expenditures, and manufacturer profit margins. The annualized change in INPV is calculated using the industry weighted average cost of capital value of 9.6 percent that is estimated in the manufacturer impact analysis (*see* chapter 12 of the final rule TSD for a complete description of the industry weighted average cost of capital). For consumer water heaters, the annualized change in INPV ranges from -$28 million to $3 million. DOE accounts for that range of likely impacts in analyzing whether a trial standard level is economically justified. *See* section V.C of this document. DOE is presenting the range of impacts to the INPV under two scenarios: the Preservation of Gross Margin scenario, which is the manufacturer markup scenario used in the calculation of Consumer Operating Cost Savings in this table; and the Preservation of Operating Profit scenario, where DOE assumed manufacturers would not be able to increase per-unit operating profit in proportion to increases in manufacturer production costs. DOE includes the range of estimated annualized change in INPV in the above table, drawing on the MIA explained further in section IV.J of this document to provide additional context for assessing the estimated impacts of this final rule to society, including potential changes in production and consumption, which is consistent with OMB's Circular A-4 and E.O. 12866. If DOE were to include the INPV into the annualized net benefit calculation for this final rule, the annualized net benefits would range from $8,037 million to $8,068 million at 3-percent discount rate and would range from $5,471 million to $5,502 million at 7-percent discount rate.

DOE's analysis of the national impacts of the adopted standards is described in sections IV.H, IV.K, and IV.L of this document.

D. Conclusion

DOE concludes that the standards adopted in this final rule represent the maximum improvement in energy efficiency that is technologically feasible and economically justified, and would result in the significant conservation of energy. Specifically with regards to technological feasibility, products achieving these standard levels are already commercially available for all product classes covered by this proposal.

As for economic justification, DOE's analysis shows that the estimated benefits of the standards exceed, to a great extent, the estimated burdens of the standards.

Using a 7-percent discount rate for consumer benefits and costs and NO_x and SO_2 reduction benefits, and a 3-percent discount rate case for GHG social costs, the estimated cost of the standards for consumer water heaters is $2,623 million per year in increased product costs, while the estimated annual benefits are $5,655 million in reduced product operating costs, $1,051 million in climate benefits, and $1,416 million in health benefits. The net benefit amounts to $5,499 million per year.

The significance of energy savings offered by a new or amended energy conservation standard cannot be determined without knowledge of the specific circumstances surrounding a given rulemaking.[12] For example, some covered products and equipment have most of their energy consumption occur during periods of peak energy demand. The impacts of these products on the energy infrastructure can be more pronounced than products with relatively constant demand. Accordingly, DOE evaluates the significance of energy savings on a case-by-case basis.

As previously mentioned, the standards are projected to result in estimated cumulative national energy savings of 17.6 quads (full-fuel cycle ("FFC")), the equivalent of the primary annual energy use of 116 million homes. In addition, they are projected to reduce CO_2 emissions by 332 Mt. Based on these findings, DOE has determined the energy savings from the standard levels adopted in this final rule are

[12] Procedures, Interpretations, and Policies for Consideration in New or Revised Energy Conservation Standards and Test Procedures for Consumer Products and Commercial/Industrial Equipment, 86 FR 70892, 70901 (Dec. 13, 2021).

"significant" within the meaning of 42 U.S.C. 6295(o)(3)(B). A more detailed discussion of the basis for these conclusions is contained in the remainder of this document and the accompanying TSD.

II. Introduction

The following section briefly discusses the statutory authority underlying this final rule, as well as some of the relevant historical background related to the establishment of standards for consumer water heaters.

A. Authority

EPCA authorizes DOE to regulate the energy efficiency of a number of consumer products and certain industrial equipment. Title III, Part B of EPCA established the Energy Conservation Program for Consumer Products Other Than Automobiles. These products include consumer water heaters, the subject of this document. (42 U.S.C. 6292(a)(4)) EPCA prescribed energy conservation standards for these products (42 U.S.C. 6295(e)(1)), and directs DOE to conduct future rulemakings to determine whether to amend these standards. (42 U.S.C. 6295(e)(4)) EPCA further provides that, not later than 6 years after the issuance of any final rule establishing or amending a standard, DOE must publish either a notice of determination that standards for the product do not need to be amended, or a NOPR including new proposed energy conservation standards (proceeding to a final rule, as appropriate). (42 U.S.C. 6295(m)(1))

The energy conservation program under EPCA, consists essentially of four parts: (1) testing, (2) labeling, (3) the establishment of Federal energy conservation standards, and (4) certification and enforcement procedures. Relevant provisions of the EPCA specifically include definitions (42 U.S.C. 6291), test procedures (42 U.S.C. 6293), labeling provisions (42 U.S.C. 6294), energy conservation standards (42 U.S.C. 6295), and the authority to require information and reports from manufacturers (42 U.S.C. 6296).

Federal energy efficiency requirements for covered products established under EPCA generally supersede State laws and regulations concerning energy conservation testing, labeling, and standards. (42 U.S.C. 6297(a)-(c)) DOE may, however, grant waivers of Federal preemption in limited instances for particular State laws or regulations, in accordance with the procedures and other provisions set forth under EPCA. (*See* 42 U.S.C. 6297(d))

Subject to certain statutory criteria and conditions, DOE is required to develop test procedures to measure the energy efficiency, energy use, or estimated annual operating cost of each covered product. (42 U.S.C. 6295(o)(3)(A) and 42 U.S.C. 6295(r)) Manufacturers of covered products must use the prescribed DOE test procedure as the basis for certifying to DOE that their products comply with the applicable energy conservation standards adopted under EPCA and when making representations to the public regarding the energy use or efficiency of those products. (42 U.S.C. 6293(c) and 6295(s)) Similarly, DOE must use these test procedures to determine whether the products comply with standards adopted pursuant to EPCA. (42 U.S.C. 6295(s)) The DOE test procedures for consumer water heaters appear at title 10 of the Code of Federal Regulations ("CFR") part 430, subpart B, appendix E ("appendix E").

DOE must follow specific statutory criteria for prescribing new or amended standards for covered products, including consumer water heaters. Any new or amended standard for a covered product must be designed to achieve the maximum improvement in energy efficiency that the Secretary of Energy determines is technologically feasible and economically justified. (42 U.S.C. 6295(o)(2)(A)) Furthermore, DOE may not adopt any standard that would not result in the significant conservation of energy. (42 U.S.C. 6295(o)(3))

Moreover, DOE may not prescribe a standard (1) for certain products, including consumer water heaters, if no test procedure has been established for the product, or (2) if DOE determines by rule that the standard is not technologically feasible or economically justified. (42 U.S.C. 6295(o)(3)(A)–(B)) In deciding whether a proposed standard is economically justified, DOE must determine whether the benefits of the standard exceed its burdens. (42 U.S.C. 6295(o)(2)(B)(i)) DOE must make this determination after receiving comments on the proposed standard, and by considering, to the greatest extent practicable, the following seven statutory factors:

1) The economic impact of the standard on manufacturers and consumers of the products subject to the standard;

2) The savings in operating costs throughout the estimated average life of the covered products in the type (or class) compared to any increase in the price, initial charges, or maintenance expenses for the covered products that are likely to result from the standard;

3) The total projected amount of energy (or as applicable, water) savings likely to result directly from the standard;

4) Any lessening of the utility or the performance of the covered products likely to result from the standard;

5) The impact of any lessening of competition, as determined in writing by the Attorney General, that is likely to result from the standard;

6) The need for national energy and water conservation; and

7) Other factors the Secretary of Energy ("Secretary") considers relevant.

(42 U.S.C. 6295(o)(2)(B)(i)(I)–(VII))

Further, EPCA, as codified, establishes a rebuttable presumption that a standard is economically justified if the Secretary finds that the additional cost to the consumer of purchasing a product complying with an energy conservation standard level will be less than three times the value of the energy savings during the first year that the consumer will receive as a result of the standard, as calculated under the applicable test procedure. (42 U.S.C. 6295(o)(2)(B)(iii))

EPCA, as codified, also contains what is known as an "anti-backsliding" provision, which prevents the Secretary from prescribing any amended standard that either increases the maximum allowable energy use or decreases the minimum required energy efficiency of a covered product. (42 U.S.C. 6295(o)(1)) Also, the Secretary may not prescribe an amended or new standard if interested persons have established by a preponderance of the evidence that the standard is likely to result in the unavailability in the United States in any covered product type (or class) of performance characteristics (including reliability), features, sizes, capacities, and volumes that are substantially the same as those generally available in the United States. (42 U.S.C. 6295(o)(4))

Additionally, EPCA specifies requirements when promulgating an energy conservation standard for a covered product that has two or more subcategories. DOE must specify a different standard level for a type or class of products that has the same function or intended use if DOE determines that products within such group (A) consume a different kind of energy from that consumed by other covered products within such type (or class); or (B) have a capacity or other performance-related feature which other products within such type (or class) do not have and such feature justifies a higher or lower standard. (42 U.S.C. 6295(q)(1)) In determining whether a performance-related feature justifies a different standard for a group of products, DOE must consider such factors as the utility to the consumer of such a feature and other factors DOE deems appropriate. *Id*. Any rule prescribing such a standard must include an explanation of the basis on which such higher or lower level was established. (42 U.S.C. 6295(q)(2))

Finally, pursuant to the amendments contained in the Energy Independence and Security Act of 2007 (EISA 2007), Pub. L. 110-140, any final rule for new or amended energy conservation standards promulgated after July 1, 2010, is required to address standby mode and off mode energy use. (42 U.S.C. 6295(gg)(3)) Specifically, when DOE adopts a standard for a covered product after that date, it must, if justified by the criteria for adoption of standards under EPCA (42 U.S.C. 6295(o)), incorporate standby mode and off mode energy use into a single standard, or, if that is not feasible, adopt a separate standard for such energy use for that product. (42 U.S.C. 6295(gg)(3)(A)-(B)) In this rulemaking, DOE is applying the UEF metric (which addresses standby mode and off mode energy use) to all product classes of consumer water heaters, including those product classes for which there are no currently applicable UEF-based standards.

B. Background

1. Current Standards

As directed by EPCA (42 U.S.C. 6295(e)(4)), DOE conducted two cycles of rulemakings to determine whether to amend the statutory standards for consumer water heaters found in 42 U.S.C. 6295(e)(1). The most recent rulemaking from April 2010 resulted in amended standards using the energy factor ("EF") metric originally prescribed by EPCA with a requirement for compliance starting on April 16, 2015. 75 FR 20112 (the "April 2010 Final Rule"). Later amendments to EPCA directed DOE to establish a uniform efficiency metric for consumer water heaters (*see* 42 U.S.C. 6295(e)(5)(B)).[13] The Federal test procedure was revised to use a new metric, UEF, in a final rule published on July 11, 2014 (the "July 2014 UEF TP Final Rule"). 79 FR 40542. In a final rule published in the *Federal Register* on December 29, 2016, the existing EF-based energy conservation standards were then translated from EF to UEF using a "conversion factor" method for water heater basic models that were in existence at the time. 81 FR 96204 ("December 2016 Conversion Factor Final Rule").

[13] The requirement for a consumer water heater test procedure using uniform energy factor as a metric, as well as the requirement for DOE to undertake a conversion factor rulemaking to translate existing consumer water heater standards denominated in terms of EF to ones denominated in terms of UEF, were part of the amendments to EPCA contained in the American Energy Manufacturing Technical Corrections Act (AEMTCA), Public Law 112-210 (Dec. 18, 2012).

These standards are set forth in DOE's regulations at 10 CFR 430.32(d) and are repeated in Table II.1.

Table II.1 Current UEF-Based Federal Energy Conservation Standards for Consumer Water Heaters

Product Class	Rated Storage Volume and Input Rating *(if applicable)*	Draw Pattern*	Uniform Energy Factor**
Gas-fired Storage Water Heater	≥ 20 gal and ≤ 55 gal	Very Small	$0.3456 - (0.0020 \times V_r)$
		Low	$0.5982 - (0.0019 \times V_r)$
		Medium	$0.6483 - (0.0017 \times V_r)$
		High	$0.6920 - (0.0013 \times V_r)$
	> 55 gal and ≤ 100 gal	Very Small	$0.6470 - (0.0006 \times V_r)$
		Low	$0.7689 - (0.0005 \times V_r)$
		Medium	$0.7897 - (0.0004 \times V_r)$
		High	$0.8072 - (0.0003 \times V_r)$
Oil-fired Storage Water Heater	≤ 50 gal	Very Small	$0.2509 - (0.0012 \times V_r)$
		Low	$0.5330 - (0.0016 \times V_r)$
		Medium	$0.6078 - (0.0016 \times V_r)$
		High	$0.6815 - (0.0014 \times V_r)$
Electric Storage Water Heaters	≥ 20 gal and ≤ 55 gal	Very Small	$0.8808 - (0.0008 \times V_r)$
		Low	$0.9254 - (0.0003 \times V_r)$
		Medium	$0.9307 - (0.0002 \times V_r)$
		High	$0.9349 - (0.0001 \times V_r)$
	> 55 gal and ≤ 120 gal	Very Small	$1.9236 - (0.0011 \times V_r)$
		Low	$2.0440 - (0.0011 \times V_r)$
		Medium	$2.1171 - (0.0011 \times V_r)$
		High	$2.2418 - (0.0011 \times V_r)$
Tabletop Water Heater	≥ 20 gal and ≤ 120 gal	Very Small	$0.6323 - (0.0058 \times V_r)$
		Low	$0.9188 - (0.0031 \times V_r)$
		Medium	$0.9577 - (0.0023 \times V_r)$
		High	$0.9884 - (0.0016 \times V_r)$
Instantaneous Gas-fired Water Heater	< 2 gal and >50,000 Btu/h	Very Small	0.80
		Low	0.81
		Medium	0.81
		High	0.81
Instantaneous Electric Water Heater	< 2 gal	Very Small	0.91
		Low	0.91
		Medium	0.91
		High	0.92
Grid-enabled Water Heater	> 75 gal	Very Small	$1.0136 - (0.0028 \times V_r)$
		Low	$0.9984 - (0.0014 \times V_r)$
		Medium	$0.9853 - (0.0010 \times V_r)$
		High	$0.9720 - (0.0007 \times V_r)$

* The draw pattern dictates the frequency and duration of hot water draws during the 24-hour simulated use test, and is an indicator of delivery capacity of the water heater. Draw patterns are assigned based on the first hour rating ("FHR"), for non-flow-activated water heaters, or maximum GPM rating ("Max GPM"), for flow-activated water heaters. For the specific FHR and Max GPM ranges which correspond to each draw pattern, see section 5.4.1 of Appendix E to Subpart B of 10 CFR 430.
** V_r is the rated storage volume (in gallons), as determined pursuant to 10 CFR 429.17.

In the December 2016 Conversion Factor Final Rule, DOE declined to develop conversion factors and UEF-based standards for consumer water heaters of certain sizes (by rated storage volume or input rating) and of certain types (*i.e.*, oil-fired instantaneous water heaters) where models did not exist on the market at the time to inform the analysis of the standards conversion. 81 FR 96204, 96210-96211. For consumer water heaters that did not receive converted UEF-based standards, DOE provided its interpretation that the original statutory standards—found at 42 U.S.C. 6295(e)(1) and expressed in terms of the EF metric—still applied; however, DOE would not enforce those statutorily-prescribed standards until such a time conversion factors are developed for these products and they can be converted to UEF. *Id*. Thus, the EF-based standards specified by EPCA apply to any consumer water heaters which do not have UEF-based standards found at 10 CFR 430.32(d). These EF-based standards are set forth at 42 U.S.C. 6295(e)(1) and are repeated in Table II.2.

Table II.2 EF-Based Federal Energy Conservation Standards for Consumer Water Heaters

Product Class	**Energy Factor***
Gas water heaters	$0.62 - (0.0019 \times V_r)$
Oil water heaters	$0.59 - (0.0019 \times V_r)$
Electric water heaters	$0.95 - (0.00132 \times V_r)$

* V_r is the rated storage volume (in gallons), as determined pursuant to 10 CFR 429.17.

2. History of Standards Rulemaking for Consumer Water Heaters

On May 21, 2020, DOE initiated the current rulemaking by publishing in the *Federal Register* a request for information ("May 2020 RFI"), soliciting public comment on various aspects of DOE's planned analyses to help DOE determine whether to amend energy conservation standards for consumer water heaters. 85 FR 30853 (May 21, 2020). DOE subsequently published a notice requesting feedback on its preliminary analysis and technical support document ("preliminary TSD") on March 1, 2022 (the "March 2022 Preliminary Analysis") with a 60-day comment period. 87 FR 11327 (Mar. 1, 2022). The comment period was extended by 14 days in a notice published on May 4, 2022. 87 FR 26303.

On October 21, 2022, DOE received a set of recommendations on amended energy conservation standards for consumer water heaters from a coalition of seven public- and private-sector organizations, including two water heater manufacturers, three energy efficiency organizations, one environmental group, and one consumer organization—collectively the Joint Stakeholders[14]—which addressed standards for electric storage water heaters, gas-fired storage water heaters, and gas-fired instantaneous water heaters. This coalition's submission is herein referred to as the "Joint Stakeholder Recommendation."

On July 28, 2023, DOE published in the *Federal Register* a notice of proposed rulemaking ("July 2023 NOPR") and technical support document ("NOPR TSD") with a 60-day comment period. 88 FR 49058 (Jul. 28, 2023). In the July 2023 NOPR, DOE proposed new and amended standards for consumer water heaters and addressed stakeholder feedback on the March 2022 Preliminary Analysis, including the Joint

[14] In this final rule, "Joint Stakeholders" refers to the group of stakeholders who submitted and continued to support the October 21, 2022 comment even though the makeup of this group has changed since the July 2023 NOPR. Specifically, BWC removed itself as a signatory after the July 2023 NOPR.

Stakeholder Recommendation. On September 13, 2023, DOE presented the proposed standards and accompanying analysis at a public meeting.

DOE received 2,950 comments in response to the July 2023 NOPR from interested parties, some of which were docketed together as multiple comments or commenters, resulting in a total of 1,140 docketed items. Note that of these total comments, 2,800 comments were "form letter" email submissions. In total, four distinct form letters were received. Additionally, several commenters submitted more than one comment to the docket. DOE directly references 54 of these written submissions in this final rule, which contain substantive comments regarding product classes within the scope of this final rule and are shown in Table II.3. The remainder of the comments were from individual commenters either expressing general opposition or support for the rulemaking. Total counts of both supportive and non-supportive comments received are included in section III.A of this document.

Table II.3 List of Commenters with Written Submissions in Response to the July 2023 NOPR

Commenter(s)	Abbreviation	Comment No. in the Docket	Commenter Type
GreenTECH Innovation Corp	GreenTECH	0071	Manufacturer
Individual	Ravnitzky	0073	Individual
NPGA, APGA, AGA, and Rinnai	NPGA, APGA, AGA, and Rinnai	0441	Trade Associations and Manufacturer
Crystal IS, Inc.	Crystal	0577	Manufacturer
Uponor, Inc.	Uponor	0606	Manufacturer
American Enterprise Institute	AEI	0817	Consumer Advocate
Jackson Energy Authority	JEA	0865	Utility
Watertown Municipal Utilities	WMU	0872	Utility
Southeast Gas	Southeast Gas	0887	Utility
Sunrise Movement Pittsburgh	Sunrise Pittsburgh	0905	Consumer Advocate
Tennessee Valley Authority	TVA	0978	Utility

Commenter(s)	Abbreviation	Comment No. in the Docket	Commenter Type
National Apartment Association and National Multifamily Housing Council	NMHC and NAA	0996	Trade Association
Chesapeake Utilities Corporation	CHPK	1008	Utility
Attorneys General of NY, CO, CT, IL, ME, MD, MN, NV, OR, VT, WA, MA, PA, DC, NYC	Joint State Attorneys General	1035	State Official/Agency
Advanced Water Heating Initiative	AWHI	1036	Efficiency Organization
Eccotemp Systems, LLC	Ecotemp	1092	Manufacturer
National Rural Electric Cooperative Association	NRECA	1127	Utility Association
Gas Analytics and Advisory Services, LLC (GAAS) (Formally Gas End-use Advocacy Group GEAG)	GAAS	1139	Utility Association
National Caucus of Environmental Legislators	NCEL	1144	Utility Association

Commenter(s)	Abbreviation	Comment No. in the Docket	Commenter Type
Tennessee Attorney General's Office	Attorney General of TN	1149	State Official/Agency
Plumbing-Heating-Cooling Contractors Association	PHCC	1151	Trade Association
Midwest Energy Efficiency Alliance, Northeast Energy Efficiency Partnerships, Northwest Energy Efficiency Alliance, South-central Partnership for Energy Efficiency as a Resource, Southeast Energy Efficiency Alliance, Southwest Energy Efficiency Project	Joint Regional Advocacy Groups	1154	Efficiency Organization
American Council for an Energy-Efficient Economy, Natural Resources Defense Council, Appliance Standards Awareness Project, Northwest Energy Efficiency Alliance, Consumer Federation of America, Rheem Manufacturing	Joint Stakeholders	1156	Coalition
Puget Sound Energy, Until, Avangrid, ConEd, PG&E Corporation, National Grid, Eversource	Joint Utilities	1158	Utility Associations
153 various organizations	Joint Commenters	1159	Efficiency Organization, Coalition, Environmental/Consumer Advocate
American Supply Association	ASA	1160	Efficiency Organization
Bradford White Corporation	BWC	1164	Manufacturer
Appliance Standards Awareness Project, American Council for an Energy-Efficient Economy, CLASP, Natural Resources Defense Council, Oregon Department of Energy, Southwest Energy Efficiency Project, Washington State Department of Commerce	Joint Advocacy Groups	1165	Efficiency Organization
Air-conditioning, Heating, and Refrigeration Institute	AHRI	1167	Trade Association
RV Industry Association	RVIA	1168	Trade Association
New York State Public Service Commission	NYSPSC	1169	State Official/Agency
Association for Energy Affordability, Green & Healthy Homes Initiative, Consumer Federation of America, NC Justice Center, Consumer Reports, Pennsylvania Utility Law Project, Green Energy Consumers Alliance, Poder Latinx	Consumer Advocates	1172	Consumer Advocate
California Energy Commission	CEC	1173	State Official/Agency
Pacific Gas and Electric Company; Southern California Edison; and San Diego Gas & Electric Company	CA IOUs	1175	Utility

Commenter(s)	Abbreviation	Comment No. in the Docket	Commenter Type
Rheem Manufacturing Company	Rheem	1177	Manufacturer
American Lung Association, American Public Health Association, Asthma and Allergy Foundation of America, Climate Psychiatry Alliance, National Association of Pediatric Nurse Practitioners, Physicians for Social Responsibility, Public Health Institute	Health Advocates	1179	Consumer Advocate
AGA, APGA, NPGA, Spire	Gas Association Commenters	1181	Utility Association
A. O. Smith Corporation	A.O. Smith	1182	Manufacturer
Atmos Energy	Atmos Energy	1183	Utility
Electric Cooperatives of South Carolina	ECSC	1185	Utility Association
Rinnai America Corporation	Rinnai	1186	Manufacturer
Multiple Individual Architecture Firms	Joint Architects	1188	Trade Association
Earthjustice	Earthjustice	1189	Efficiency Organization
SkyCentrics	SkyCentrics	1191	Manufacturer
New York State Energy Research and Development Authority	NYSERDA	1192	State Official/Agency
Armada Power, LLC	Armada	1193	Manufacturer
Essency Water Heaters	Essency	1194	Manufacturer
Physicians for Social Responsibility	PSR	1196	Consumer Advocate
Individual	Stanonik	1197	Individual
Edison Electric Institute	EEI	1198	Utility Association
Northwest Energy Efficiency Alliance	NEEA	1199	Efficiency Organization
ONE Gas, Inc.	ONE Gas	1200	Utility
Noritz America Corporation	Noritz	1202	Efficiency Organization
GE Appliances, a Haier company	GEA	1203	Manufacturer
Robert Bosch LLC	Bosch	1204	Manufacturer
Vermont Department of Public Service, New Jersey Board of Public Utilities, Maine Governor's Energy Office, New York State Energy Research and Development Authority, Washington State Department of Commerce, Government of the District of Columbia, Colorado Energy Office, Maryland Energy Administration, New Mexico State Energy Office, Oregon Department of Energy	State Agencies	1213	State Official/Agency

A parenthetical reference at the end of a comment quotation or paraphrase provides the location of the item in the public record.[15] To the extent that interested parties have provided written comments that are substantively consistent with any oral comments provided during the September 13, 2023, public meeting, DOE cites the written comments throughout this final rule. Any oral comments provided during the webinar that are not substantively addressed by written comments are summarized and cited separately throughout this final rule.

Additionally, DOE received comments from stakeholders in response to the July 2023 NOPR regarding the scope and classification of circulating water heaters as defined at 10 CFR 430.2 by the June 2023 TP Final Rule. DOE subsequently published a supplemental notice of proposed rulemaking on December 27, 2023 ("December 2023 SNOPR"), that discussed the comments received on this topic and proposed to amend the definition for "circulating water heater" to reclassify these products as storage-type water heaters. 88 FR 89330. DOE received 195 comments in response to the December 2023 SNOPR from interested parties. DOE directly references 14 of these written submissions which provided remarks about the rulemaking analysis pertinent to standards for circulating water heaters or comments relevant to the issues discussed in the December 2023 SNOPR, and these submissions are shown in Table II.4.

[15] The parenthetical reference provides a reference for information located in the docket of DOE's rulemaking to develop energy conservation standards for consumer water heaters. (Docket No. EERE-2017-BT-STD-0019, which is maintained at *www.regulations.gov*). The references are arranged as follows: (commenter name, comment docket ID number, page of that document).

Table II.4 List of Commenters with Written Submissions in Response to the December 2023 SNOPR

Commenter(s)	Abbreviation	Comment No. in the Docket	Commenter Type
Individual	Great Plains Resource	1267	Individual
Individual	Johnson	1271	Individual
Individual	Harley	1341	Individual
Air-conditioning, Heating, and Refrigeration Institute	AHRI	1389	Trade Association
Francis R. Pickering	Pickering	1399	Individual
New York State Energy Research and Development Authority	NYSERDA	1406	State Official/Agency
Appliance Standards Awareness Project; American Council for an Energy-Efficient Economy; National Consumer Law Center; Natural Resources Defense Council	ASAP et al.	1407	Efficiency Organization
Rheem Manufacturing Company	Rheem	1408	Manufacturer
Pacific Gas and Electric Company; Southern California Edison; San Diego Gas & Electric Company	CA IOUs	1409	Utility
A.O. Smith Corporation	A.O. Smith	1411	Manufacturer
California Energy Commission	CEC	1412	State Official/Agency
Bradford White Corporation	BWC	1413	Manufacturer
Northwest Energy Efficiency Alliance	NEEA	1414	Efficiency Organization
Rinnai America Corporation	Rinnai	1415	Manufacturer

3. Scope of this Final Rule

Following review of comments on the July 2023 NOPR and December 2023 SNOPR, DOE has decided to finalize at this time standards for all consumer water heaters with the exception of gas-fired instantaneous water heaters, as defined in 10 CFR 430.2 and replicated in section III.B of this notice. DOE is not summarizing or responding to any comments specific to gas-fired instantaneous water heaters in this notice, nor discussing any analytical methodologies or results for this product class as DOE continues to consider the comments submitted in response to the July 2023 NOPR and December 2023 SNOPR in informing DOE's decision on amended energy conservation standards for GIWHs.

III. General Discussion

DOE developed this final rule after considering oral and written comments, data, and information from interested parties that represent a variety of interests. The following discussion addresses issues raised by these commenters.

A. General Comments

This section summarizes general comments received from interested parties regarding rulemaking timing and process.

1. General Support

In response to the July 2023 NOPR, DOE received 966[16] general comments (those which provided general remarks on the impact of the rulemaking)[17] related to product classes within the scope of this final rule, with 931, or 96 percent of, these comments expressing support of the proposed standards and a majority acknowledging the significant energy savings that would result from the adoption of the proposed standards.[18]

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[16] The number of comments reflects the number of individual party submissions. Specifically, form letters with multiple submissions count each submission individually.

[17] Commenters who are directly referenced in this final rule and appear in Table II.3 are not counted in these statistics because these submitters typically expressed detailed views that could not be generalized as either clear support or clear opposition for all aspects of the proposal.

[18] One comment in support of the proposed standards had 8,357 signatories.

NYSERDA, GreenTECH, the CA IOUs, NCEL, Joint Regional Advocacy Groups, Joint Stakeholders, Joint Utilities, Joint Commenters, Joint Advocacy Groups, NYSPSC, Consumer Advocates, Health Advocates, Joint Architects, PSR, NEEA and State Agencies all stated their support of the standards proposed in the July 2023 NOPR. These commenters highlighted the associated benefits of the proposal including utility bill savings, reduced GHG emissions, protection of human health, reduced energy consumption, and the ability to design more energy efficient buildings. (NYSERDA, No. 1192 at p. 1; GreenTECH, No. 71 at p. 1; CA IOUs, No. 1175 at pp. 1–2; NCEL, No. 1144 at p. 1; Joint Regional Advocacy Groups, No. 1154 at p. 1; Joint Stakeholders, No. 1156 at p. 1; Joint Utilities, No. 1158 at p. 1; Joint Commenters, No. 1159 at p. 1–2; Joint Advocacy Groups, No. 1165 at p. 1; NYSPSC, No. 1169 at p. 1; Consumer Advocates, No. 1172 at p. 1; Health Advocates, No. 1179 at p. 1; Joint Architects, No. 1188 at p. 1; PSR, No. 1196 at p. 1–2; NEEA, No. 1199 at p. 2; State Agencies, No. 1213 at p. 1-2)

NCEL noted that, according to a report by the Appliance Standards Awareness Project, water heaters represent the largest potential for emissions reductions among regulated consumer products, and the proposed standards would reduce CO_2 emissions by more than 500 Mt over 30 years of sales, helping the United States meet its climate goals. (NCEL, No. 1144 at p. 1) The Joint Regional Advocacy Groups supported, specifically, the proposed standards for electric storage water heaters at heat pump efficiency levels. (Joint Regional Advocacy Groups, No. 1154 at p. 1) The Joint State Attorneys General also commented in support of the proposed standards for consumer water heaters and recommended that DOE finalize the proposed rule as soon as possible. The Joint State Attorneys General further emphasized that the proposed standards would significantly improve the energy efficiency of both electric and gas water heaters while providing economic benefits to consumers. The Joint State Attorneys General stated that the proposed standards for consumer water heaters are projected to yield significant environmental benefits, climate benefits, and monetized health benefits. The Joint State Attorneys General also commented that the transition to more efficient consumer water heating will be increasingly cost effective and affordable as time progresses, particularly considering the Federal investment in weatherization, energy efficiency, and beneficial electrification programs that would help address cost concerns related to installing new or replacement products. (Joint State Attorneys General, No. 1035 at pp. 1–3) State Agencies claimed that while State regulations have the potential to reduce GHG emissions, individual States cannot adopt standards for products for which the Federal government has promulgated an existing standard (such as consumer water heaters) and that collaboration is required for impactful climate action. (State Agencies, No. 1213 at p. 1) DOE understands the commenter to be referring to provisions at 42 U.S.C. 6297, by which Federal energy standards supersede State regulations with exceptions for certain products that do not include consumer water heaters. State Agencies also indicated that the proposed standards would reduce the energy burden for low-income households, which spend larger portions of their income on energy bills. (State Agencies, No. 1213 at p. 2)

Rheem generally supported DOE's proposed amended standards and the analysis behind them but expressed concern regarding potential unintended consequences of the proposed standards for certain product classes caused in part by the application of the high-temperature test method and effective storage volume metric. Rheem suggested possible solutions to resolve these issues, which are discussed further in section V.D of this document. (Rheem, No. 1177 at p. 1) Rheem stated that, for electric storage water heaters between 20 and 120 gallons (except for small electric storage water heaters), heat pump-level standards are appropriate. Rheem recommended that DOE act to prevent a market shift away from heat pump technologies if standards are amended to require this for a larger fraction of the electric storage water heater market because not only would it result in reduction of energy savings, but it also would pose a risk to manufacturers' return on investment in heat pump water heater development in a timely manner. Rheem noted that there would be significant changes to product design and manufacturing facilities as a result of a heat pump standard in this rulemaking. (*Id.* at p. 7)

The Joint Stakeholders stated that the proposed standards for gas-fired water heaters are consistent with their recommendations and noted that the proposal follows the established rationale that separate standards be maintained for gas-fired storage water heaters and their instantaneous counterparts. (Joint Stakeholders, No. 1156 at p. 2) NEEA, the Joint Regional Advocacy Groups (citing the estimated FFC and monetary savings), and Bosch supported the proposed standards for gas-fired storage water heaters. (NEEA, No. 1199 at p. 9; Joint Regional Advocacy Groups, No. 1154 at p. 1; Bosch, No. 1204 at p. 2)

The CA IOUs encouraged DOE to set more stringent standards for gas-fired storage water heaters. According to the CA IOUs, more stringent standards for all gas-fired consumer water heater sub-classes, specifically at condensing efficiencies, would result in significant savings of natural gas in California and across the United States. (CA

IOUs, No. 1175 at p. 2) AWHI also encouraged DOE to set more stringent standards for gas-fired storage water heaters. (AWHI, No. 1036 at pp. 3–4)

NYSERDA stated that the proposals in the July 2023 NOPR substantially aligned with the Joint Stakeholder Recommendation, which was supported by NYSERDA. The commenter noted that, by allowing less stringent standards for small electric storage water heaters, DOE would ensure that there are replacement units available for lowboy water heaters, while still allowing innovation and expansion for heat pump water heaters. (NYSERDA, No. 1192 at p. 2)

Additionally, some commenters offered general support in response to the December 2023 SNOPR.

NYSERDA commented that the proposals in the December 2023 SNOPR fully address their concerns raised at the NOPR stage regarding the potential use of electric resistance circulating water heaters in place of heat pump electric storage water heaters. (NYSERDA, No. 1406 at p. 2) NEEA expressed support for the changes proposed in the December 2023 SNOPR and urged DOE to move forward with these proposals, as well as those made in the July 2023 NOPR. (NEEA, No. 1414 at p. 1) NEEA reiterated its support for effective storage volume-based standards and high temperature test methods to prevent small, overheated products from being used in place of products that meet the proposed standards. (NEEA, No. 1414 at p. 2) CEC reiterated its appreciation for DOE's efforts to address potential loopholes in the proposed regulatory language for circulating water heaters and high temperature test methods. (CEC, No. 1412 at p. 2)

2. General Opposition

Of the 966 general comments DOE received in response to the July 2023 NOPR related to product classes within the scope of this final rule, 29, or 3 percent, were in opposition of new standards, with the majority of opposition comments focused on the concerns of government overreach and interference with a free market, impacts on product cost, and overestimation of energy savings. Commenters also expressed concerns about potential outsourcing to foreign companies due to the proposed standards, installation costs for gas-fired and heat pump water heaters, and the performance of heat pump water heaters. These topics are discussed in this section through section III.A.3 of this document.

Ravnitzky supported DOE's efforts to improve the energy efficiency of consumer water heaters and reduce greenhouse gas emissions but expressed concern for the impact of the proposed standards on consumers and manufacturers. Ravnitzky urged DOE to reconsider the proposed standards and account for the efficiency potential and resiliency benefits of non-heat pump water heaters. (Ravnitzky, No. 73 at p. 1)

Ravnitzky stated that the proposed standards do not account for the resiliency benefits of non-heat pump water heaters, which can operate without electricity. Ravnitzky stated that heat pump water heaters cannot function during a power outage, which could inconvenience consumers and result in health risks. Ravnitzky also stated that gas-fired water heaters are beneficial to consumers prone to natural disasters and extreme weather events that disrupt the power grid because they do not require electricity to operate. (Ravnitzky, No. 73 at p. 1)

Throughout this rulemaking, DOE has assessed the impacts of potential amended standards on consumers and manufacturers, specifically quantifying these impacts as national benefits and costs (*see* section I of this document). In response to the concerns raised by Ravnitzky, DOE notes that gas-fired water heaters will still be available as an option to consumers at the levels adopted in this final rule. Further, DOE notes that, while for certain classes of electric storage water heaters the adopted standards are currently only met through use of heat pump technology, electric storage water heaters that rely on electric resistance technology also require a continuous supply of electricity to operate. Therefore, without a backup supply of electricity a power outage would render both types of electric storage water heaters inoperable. DOE also notes that some gas-fired water heaters do require electricity to operate. However, as discussed in the July 2023 NOPR, DOE maintains its interpretation of EPCA at 42 U.S.C. 6295(q)(1) that gas-fired water heaters that do not require electricity should not be treated differently (*i.e.*, constitute a separate product class) from gas-fired water heaters that do. 88 FR 49058, 49079.

AEI stated its belief that the rule is based on the need to confront the global climate crisis, and therefore it is fatally flawed and should not be finalized due to the lack of evidence of a climate "threat" or "crisis." (AEI, No. 817 at p. 2)

DOE is finalizing amendments to the test procedure and energy conservation standards for consumer water heaters based on its authority described in section II.A, which requires the Department to consider seven (7) factors prior to finalizing such amendments. This final rule outlines DOE's analysis of all seven factors, with additional details provided in the TSD.

The Attorney General of TN commented that the proposed standards have significant federalism implications within the meaning of Executive Order 13132 for the following reasons: (1) DOE's standards have a preemptive effect on States' procurement standards; and (2) States own and purchase water heaters, and therefore the proposed standards' effect on water heater costs directly affect States as purchasers. (Attorney General of TN, No. 1149 at pp. 2–3) The Attorney General of TN commented that DOE must show that the intrastate activity covered by the proposed standards substantially affects the interstate market for water heaters and there is no such analysis in the July 2023 NOPR. The Attorney General of TN commented that the proposed standards will dominate the regulation of consumer goods—authority traditionally belonging to the States. (Attorney General of TN, No. 1149 at p. 3)

DOE responds that it believes the scope of both the standard proposed in the July 2023 NOPR and the amended standard adopted in this final rule properly includes all consumer water heaters distributed in commerce for personal use or consumption because intrastate state activity regulated by 42 U.S.C. 6291(17) and 6302 is inseparable from and substantially affects interstate commerce. DOE has clear authority under EPCA to regulate the energy use of a variety of consumer products and certain commercial and industrial equipment, including the subject consumer water heaters. See 42 U.S.C. 6295. Based on this statutory authority, DOE has a long-standing practice of issuing energy conservation standards with the same scope as the standard in this final rule. For example, DOE has maintained a similar scope of products in the April 2010 Final Rule and in the December 2016 Conversion Factor Final Rule. DOE disagrees with the Attorney General of TN's contention that the Commerce Clause, the Tenth Amendment, the Major Questions Doctrine, or any canons of statutory construction limit DOE's clear and long-standing authority under EPCA to adopt the standard, including its scope, in this final rule. A further discussion regarding the Attorney General of TN's Federalism concerns can be found at section VI.E of this document.

BWC, a former signatory to the Joint Stakeholder Recommendation, urged DOE to reconsider re-aligning certain aspects of its proposal to what was originally recommended by the Joint Stakeholder Recommendation. (BWC, No. 1164 at p. 1)

The July 2023 NOPR proposed product classes and efficiency levels incorporating the feedback from the Joint Stakeholder Recommendation; however, the Department did not align entirely with the Joint Stakeholder Recommendation. DOE provided its rationale for product class definitions, efficiency level selection, and effective storage volume throughout the July 2023 NOPR (*see* section IV of the July 2023 NOPR). These topics are discussed further in this final rule in sections IV.A.1.f, IV.C.1.a, and V.D.1 of this document, respectively.

BWC noted that the July 2023 NOPR was published only shortly after the June 2023 TP Final Rule, and that this period of time was too short for manufacturers to provide adequate feedback on new aspects of the test procedure, such as effective storage volume and high temperature testing. BWC expressed its concern over this and the 60-day comment period provided for the July 2023 NOPR, noting that these were both deviations from appendix A. The Gas Association Commenters and Rinnai also commented on this deviation, with ASA and the Gas Association Commenters stating that the 60-day comment period was insufficient to develop responses to the July 2023

NOPR and Rinnai stating that DOE did not have an adequate basis to depart from the standard 75-day comment period. ASA recommended extending the comment period to provide commenters additional time for research and feedback and the Gas Association Commenters stated this deviation placed undue burden on commenters to review and evaluate a proposal that could have significant ramifications on the water heater industry and consumers. Rinnai claimed that DOE has rushed the rulemaking process by relying on a preliminary TSD from 2022 and not producing a final TSD with the July 2023 NOPR and believed the compressed schedule between the September 2023 Webinar and the end of the comment period was unjustified (BWC, No. 1164 at pp. 6–7; Gas Association Commenters, No. 1181, pp. 37–38; Rinnai, No. 1186 at p. 35; ASA, No. 1160 at p. 1) JEA, WMU, and Southeast Gas commented that as members of APGA, they supported APGA's submitted comments that offer more details on their concerns. (JEA, No. 865 at p. 2; WMU, No. 872 at p. 2; Southeast Gas, No. 887 at p. 1)

DOE has determined that the length of the comment period was appropriate and provided a meaningful opportunity to comment on the NOPR. In the July 2023 NOPR, DOE explained its deviation from section 6(f)(2) of 10 CFR Part 430, subpart C, appendix A,[19] which specifies that the length of the public comment period for a NOPR be not less than 75 calendar days. However, with respect to NOPRs, EPCA requires at least a 60-day comment period. (42 U.S.C. 6295(p)(2)), and similarly, Executive Order ("E.O.") 12866, "Regulatory Planning and Review," 58 FR 51735 (Oct. 4, 1993) states that in most cases a comment period should not be less than 60 days. On April 8, 2024, DOE published in the *Federal Register* a final rule amending section 6 of appendix A to

[19] In reference to appendix A as it appeared at the time of the publication of the July 2023 NOPR.

specify that comment periods for standards rulemaking documents will be determined on a case-by-case basis with a minimum 60-day comment period for NOPRs based on the requirements of EPCA and recommendations in E.O. 12866. 89 FR 24360 (April 8, 2024). As discussed in the July 2023 NOPR, DOE determined that a 60-day comment period provided sufficient time because the NOPR relied on many of the same analytical assumptions and approaches as used in the preliminary assessment, on which the public had an opportunity to comment. 88 FR 49058. In particular, a 60-day comment period (followed by 14-day extension) was provided for the March 2022 Preliminary Analysis, and a 45-day period for the May 2020 RFI. 87 FR 11327; 85 FR 30853.

In response to the December 2023 SNOPR, DOE received 176 comments, or 90 percent of comments, in opposition of new standards along similar concerns as those expressed in response to the July 2023 NOPR.

DOE also received feedback from some stakeholders that the comment period provided for the December 2023 SNOPR was too short. AHRI requested that DOE extend the comment period to provide stakeholders adequate time to properly respond. (AHRI, No. 1389 at p. 1) BWC stated that the opportunity to comment on the December 2023 SNOPR was severely limited due to its seasonal timing and comment period duration. (BWC, No. 1413 at p. 3) Rinnai stated that there was little meaningful time for a detailed assessment of the December 2023 SNOPR due to the timing of the comment period and that only a limited number of inputs were collected. (Rinnai, No. 1415 at p. 1)

The scope of the December 2023 SNOPR was limited to a definitional change for circulating water heaters, with only two requests for comment, and therefore DOE believes the comment period was sufficient. The CA IOUs, NEEA, CEC, and NYSERDA expressed support for the December 2023 SNOPR comment period being limited to 14 days because its scope is limited to circulating water heaters. (CA IOUs, No. 1409 at p. 1; NEEA, No. 1414 at p. 2; CEC, No. 1412 at p. 3; NYSERDA, No. 1406 at p. 1)

Additionally, DOE's proposal in the SNOPR was mainly responsive to more substantive stakeholder feedback received in response to the July 2023 NOPR, as discussed throughout that notice (*see* 88 FR 89330).

Many individual commenters also expressed concerns regarding the implementation of heat pump water heaters due to efficiency concerns in colder areas and weather, lack of expertise in maintaining a more complex product, reliability, potential for mold, and potentially high purchase and installation costs and requirements for a product with the same expected lifetime as a standard electric water heater. Individual commenters also stated that the proposed standards are counterproductive because heat pump water heaters eject cold air into the house which then has to be heated up by the household HVAC system. Individual commenters stated that consumers may face high costs and long wait times associated with retrofitting due to the proposed standards, and due to increased insulation, which results in larger products. These high costs will increase the cost of home ownership and may prevent first-time buyers from obtaining a home.

DOE accounts for differences between rated efficiency and on-site efficiency in its energy use analysis, which considers factors like climate and heating load. Heat pump water heaters can help with cooling demand in the summer but can work against the home heating system in the winter if they are not ducted separately. DOE's energy use analysis includes these impacts (*see* appendix 7B to the TSD). DOE quantifies these impacts in the energy use analysis to include them in the expected operating expenses for the LCC analysis.

One individual commenter requested that equipment and repair costs be factored into savings and that consumers should decide the return in savings when investing in new equipment. (Johnson, No. 1271 at p. 1) Great Plains Resource supported the proposed standard and stated that if a redesign of water heaters helps to control pollution, it should be passed. Great Plains Resource stated, however, that DOE should plan to mitigate costs for consumers associated with manufacturers increasing costs of water heaters. Other commenters suggested that DOE subsidize new water heater technologies or introduce a tax incentive rather than seeking energy efficiency through regulations. Great Plains Resource suggested that DOE should consider extending the time frame to help manufacturers create new equipment and create competition to control cost of equipment to consumers. (Great Plains Resource, No. 1267 at p. 1) An individual commented that condensing gas-fired water heaters use expensive vent pipes due to the corrosiveness of condensation. (Harley, No. 1341 at p. 1)

DOE notes that its analysis incorporates installation and equipment costs into its analysis, including the necessary venting, as well as repair and maintenance costs. Pickering expressed concern that the definitions proposed in the December 2023 SNOPR for circulating water heaters may not be compatible with solar photovoltaic direct water heating systems, which the commenter described as a low-cost system where DC electric output from the solar photovoltaic panel is wired (without grid connection) directly to the heating elements of an electric resistance storage water heater. (Pickering, No. 1399, at pp. 1-3)

DOE understands this comment to be opposing the proposed heat pump-level standards for most electric storage water heaters due to the fact that the direct solar photovoltaic water heating systems described by the commenter is dependent upon a DC-compatible electric storage water heater. DOE notes that electric resistance storage water heaters will still be available within the small electric storage water heater (and grid-enabled water heater product classes for cases where the home is still connected to a utility grid), however.

According to NPGA, APGA, AGA, and Rinnai, DOE is seeking to promote the market for electric heat pumps at the expense of gas-fired water heaters, diminishing competition and profoundly affecting consumer choice. They also stated that the proposed rule fails to meet EPCA's 3-year rebuttable presumption of economic justification under pure economic terms and would be an enormous burden on manufacturing and on competition between gas and electric water heaters. (NPGA, APGA, AGA, and Rinnai, No. 441 at pp. 3–4) EEI noted that while the proposed standards for electric storage water heaters increase by 21 to 140 percent in efficiency, the July 2023 NOPR only proposed an increase of 0 to 9.7 percent for gas-fired and oil-fired storage water heaters, and this disparity would cause fuel-fired storage water heaters to gain a competitive advantage because buyers' decisions are strongly motivated by cost considerations. (EEI, No. 1198 at pp. 3–4) Sunrise Pittsburgh stated that the proposed standard would require electric and gas-fired water heaters to meet vastly different standards, which could potentially result in consumers switching to gas-fired water heaters given the lower upfront cost associated with gas-fired water heaters compared to heat pump water heaters. In turn, Sunrise Pittsburgh stated this may result in more carbon emissions. According to Sunrise Pittsburgh, revising the proposed standard to apply the same standard across all water heaters regardless of the technology or fuel source used would benefit consumers, especially it removes gas-fired water heaters from the market, as this would save consumers from asthma and carcinogens as well as dangerous gas-fired water heater explosions associated with gas fueled products. (Sunrise Pittsburgh, No. 905 at pp. 1–2)

In this rulemaking DOE has provided its analytical approach and results which have led to the selection of more stringent standards for some product classes compared to others. When determining whether the benefits of amended standards outweigh the burdens, DOE considers the trial standards levels, which are comprised of different efficiency levels for each product class. The construction of trial standards levels is discussed in section V.A of this document. In the shipments analysis, which is detailed in section IV.G, DOE considers the impacts of product life-cycle costs on consumer purchasing decisions, which ultimately is used to assess the total energy savings, economic impacts to consumers, and impacts to health (summarized in section I.C).

With respect to Sunrise Pittsburgh's suggestion to apply the same standard across all water heaters regardless of the technology or fuel source, DOE establishes separate standards for different product classes of consumer water heaters based on statutory requirements from EPCA, which includes a consideration for products that consume different types of energy (*e.g.*, electricity, oil, or gas). (42 U.S.C. 6295(q)(1)-(2)) The product classes established by this final rule are discussed in section IV.A.1 of this document.

3. Selection of Standards Levels

DOE received several comments regarding the selection of proposed efficiency levels.

CEC agreed with DOE's analysis recognizing that the majority of electric storage water heaters can meet heat pump-level standards but encouraged DOE to consider improving the minimum standard for electric storage water heaters > 20 and ≤ 55 gal to a level closer to EL 2. CEC noted that while a UEF of 2.3 (as proposed) is sufficient to drive the core shift in technology, the least efficient heat pump water heaters on the market today have a UEF of 2.8 or greater. (CEC, No. 1173 at pp. 3–4)

As stated in the July 2023 NOPR, split-system and 120-volt heat pump water heaters may not be able to achieve the same efficiency levels as conventional 240-volt products, as suggested by less stringent ENERGY STAR Residential Water Heaters Specification Version 5.0 ("ENERGY STAR v5.0") criteria at 2.20 UEF. DOE has observed products certified to both the ENERGY STAR database and DOE's Compliance Certification Database ("CCD") capable of meeting these criteria and determined EL 2 such that novel 120-volt products would not be prevented from entering the market. 88 FR 49058, 49090. DOE continued to consider these factors when evaluating the standard levels for this final rule.

DOE received comments from BWC regarding the potential manufacturer impacts and capacity constraints related to transitioning all electric storage water heater products to heat pump designs. BWC stated appreciation that DOE recognized that a 5-year compliance window may be challenging for many manufacturers to redesign 100 percent of electric storage water heater products to incorporate heat pump designs. BWC noted that change of this scale would indeed require a commitment of significant time, resources, and capital to ensure these units can be produced at a rate that would satisfy sharply increased demand while meeting and exceeding consumers' needs and expectations. (BWC, No. 1164 at pp. 14-15)

NRECA recommended that DOE delay implementation of the proposed electric storage water heater standard for 40-gallon model sizes to allow more time for manufacturers to innovate and design heat pump water heaters that are more adaptable to a variety of installation scenarios. NRECA also recommended that DOE allow electric resistance options for storage tank sizes up to 50 gallons for space constrained installations, and that DOE apply the proposed standard for electric storage water heaters to new construction only, since new homes can be designed to accommodate heat pump water heaters. (NRECA, No. 1127 at p. 13)

In response, DOE notes that the timing of amended standards for consumer water heaters is mandated by EPCA. Furthermore, DOE finds that a 5-year lead time is sufficient for manufacturers to prepare given that heat pump water heaters available today can be installed in a variety of installation scenarios. For consumer water heaters DOE does not have the authority to regulate water heaters in new construction only. As discussed in section V.C of this document, DOE has fully weighed the burdens of its proposed standards for electric storage water heaters against its benefits in determining the appropriate standards level.

DOE acknowledges that requiring all electric storage water heater products to utilize heat pump designs would require notably higher levels of investment and development effort compared to only requiring a portion of the electric storage water heater market to transition to heat pump designs. In this final rule, DOE is adopting TSL 2, which, for electric storage water heaters, includes standards for larger products that are met through the use of heat pump technology while leaving standards for smaller products that can be met through the use of electric resistance heating. *See* section V.C.1 of this document for the benefits and burdens of the TSLs considered in this rulemaking.

In this rulemaking, DOE did not analyze more stringent standards for product classes for which there are currently no UEF-based standards. Several commenters raised the concern that establishing such standards for certain product classes and then raising standards for other product classes would create a market condition where manufacturers can shift their models to meet the requirements of the new product classes with less stringent standards, hence undermining the energy savings potential of this rulemaking. This issue is discussed in detail throughout this document. The creation of separate product classes for the models that do not have current UEF-based standards is detailed in section IV.A.1. The selection of standards for these products is explained in section IV.C.1. Finally, the impact of market transition (*i.e.*, product class switching) is addressed in the shipments analysis in section IV.G of this document.

DOE received comments from some stakeholders regarding the impact of the proposed standards for electric storage water heaters (which correspond to efficiencies attainable by heat pump water heaters) on electric grids.

Armada claimed that the proposed standards would cause serious business harm to companies that provide technologies to convert traditional electric storage water heaters into demand-response products. (Armada, No. 1193 at p. 3) Armada emphasized the importance of American-made technologies for grid-reliability as critical to tackling the climate crisis and advancing environmental justice initiatives, but these technologies are at risk of being regulated out of existence by the proposed standards. (Armada, No. 1193 at p. 7) Armada commented that due to the long recovery cycle of heat pump water heaters, these products are limited in their demand response capabilities. Armada stated that while they can be used for scheduled time-of-use programs, they do not work well responding to grid congestion or to the intermittent availability of renewable energy sources (*e.g.*, wind or solar) because water heater energy use times do not line up with when renewable energy resources are available during the day. (Armada, No. 1193 at p. 3)

NRECA stated that heat pump water heaters may be beneficial to electrical grid demand peaks because they draw lower demand than electric resistance storage water heaters, however they expressed concern that heat pump water heaters may not yield enough savings for demand response programs to be cost-effective. NRECA also stated that most electric cooperatives use load control switches to manage electric water heater demand, but have found that this strategy is generally incompatible with heat pump water heaters, which take more time to reboot after a cut in power than an electric resistance storage water heater. NRECA added that heat pump water heater can be managed using more sophisticated strategies such as CTA 2045, AHRI 1430, or the manufacturer's API; however, NRECA commented that electric cooperatives are concerned about the time, expense, and security risks associated with implementing a new control strategy. (NRECA, No. 1127 at p. 11) NRECA stated many of their member electric cooperatives mitigate demand peaks by running demand response programs, using both grid-enabled water heaters and 50-gallon electric storage water heaters and added that few of the cooperatives they interviewed include or plan to include heat pump water heaters, due to incompatible load control strategies or reduced grid management benefits. (NRECA, No. 1127 at p. 11)

ECSC urged DOE to retain electric resistance options for electric storage water heater installations where heat pump water heaters impose a time-consuming, costly burden, and to consider restrictions on tankless electric water heaters instead. ECSC stated that if consumers cannot afford or install heat pump water heaters, the remaining options of a small electric storage water heater ("ESWH") or a tankless electric water heater pose a significant threat to existing electric grid demand management programs, which rely on electric storage water heaters as a thermal resource. ECSC added that the proposed standards for electric storage water heaters will likely disproportionately harm low-to-moderate income consumers. (ECSC, No. 1185 at p. 2)

NEEA, however, noted that heat pump water heaters have been successfully deployed in demand response programs in the Pacific Northwest, and added that, similar to electric resistance storage water heaters, heat pump water heaters are capable of shifting load from on-peak to off-peak hours, and are also capable of handling load-up events since they have both electric resistance backup elements and a compressor. NEEA cited a pilot program conducted by Bonneville Power Administration and Portland General Electric which enrolled 175 heat pump water heaters and 90 electric resistance water heaters in a demand response program and controlled them through 600 events over the course of 220 days. NEEA noted the pilot found that electric resistance and heat pump water heaters alike were able to reduce load substantially. (NEEA, No. 1199 at pp. 8–9)

NRECA's comment indicates that utilities may employ more strategies for water heater load management than CTA-2045 or OpenADR communication protocols. DOE reviewed load control switch technology in more detail.[20] These load control switches appear to be capable of implementing schedule-based control. However, if utilities need to cut power to water heaters at unplanned times to manage electricity demand, heat pump water heaters are expected to still be able to return to operation in a reasonable amount of time. DOE's teardown analyses of heat pump water heaters on the market show that nearly all heat pump water heater designs today have backup electric resistance elements should the household require a faster recovery rate. DOE does not expect heat pump water heaters to remove these backup elements as a result of amended standards. Additionally, DOE finds that the studies conducted by NEEA provide evidence towards the compatibility of heat pump water heaters with present-day load control strategies.

[20] See, for example, the Generac ARA Load Control Switch. Product literature can be found online at: *www.generacgs.com/wp-content/uploads/2023/04/ARA_LoadControlSwitch_SpecSheet_B-1.pdf* (Last accessed Oct. 11, 2023).

In response to ECSC, there is an increasing number of heat pump water heaters available with demand-response capabilities. The ENERGY STAR v5.0 specification incentivizes the manufacture of heat pump water heaters that meet a list of criteria for connected product design, including the use of the standardized CTA-2045 or OpenADR communications protocols for utilities to send signals to enrolled water heaters. Load management strategies are expected to still be compatible with heat pump water heater designs. Additionally, DOE reiterates that electric resistance storage water heaters which elevate the storage tank temperature beyond 135 °F when responding to utility load management signals are exempt from having to test to the high temperature test method and will likely remain on the market. Beyond small electric storage water heaters and heat pump water heaters, grid-enabled water heaters (which are larger than 75 gallons of rated storage volume) are designed for this explicit purpose. DOE does not expect the availability of grid-enabled water heaters to decline as a result of this final rule (because no substantial amendments to the standards for these products are being adopted in this rulemaking), so there will remain electric resistance products available to consumers to connect to utility grid programs.

NPGA, APGA, AGA, and Rinnai stated that DOE should consider the effects the additional demand for electricity for water heaters may have on the energy grid as it has presently failed to consider such an impact its proposed standards may have on grid reliability. According to NPGA, APGA, AGA, and Rinnai, DOE should heed the guidance of the Government Accountability Office and analyze options for grid resilience to avoid enhanced strain without a demand management or supply plan and would benefit by reviewing analysis of grid strain during extreme weather events. (NPGA, APGA, AGA, and Rinnai, No. 441 at p. 4) NMHC and NAA also advised that such an increase in electric product usage should be coupled with efforts to ensure the electric grid is prepared and suggested that DOE consider the costs and barriers in this rulemaking. (NMHC and NAA, No. 996 at p. 5)

DOE does not expect a significant fraction of consumers to switch from gas-fired or oil-fired water heaters to electric water heaters as a result of this rulemaking. *See* section IV.F.10 of this document. DOE does expect a significant fraction of consumers to switch from electric resistance storage water heaters to heat pump water heaters as a result of the more stringent standards for electric storage water heaters, however. Heat pump water heaters are significantly more efficient than electric resistance storage water heaters, and, as a result, consume significantly less electricity than electric resistance storage water heaters, which actually reduces strain on electrical grids.

The Attorney General of TN commented that the proposed rulemaking does not address the additional strain these standards would place on the national energy infrastructure and power grid. The Attorney General of TN stated that, by encouraging a 5 percent to 63 percent shift among consumers from gas-fired water heaters to those powered by electric pumps, the demand for additional electricity will place further stress on an already overworked energy grid. (Attorney General of TN, No. 1149 at p. 3)

DOE has carefully considered the potential impact of proposed standards on the national energy infrastructure and power grid. With reduced energy consumption and appropriate configuration, the proposed standards would actually benefit national energy infrastructure and power grid.

B. Scope of Coverage and Definitions

As discussed in section II.B.3, this final rule covers those consumer products that meet the definition of "water heater," as codified at 10 CFR 430.2 and as described by EPCA at 42 U.S.C. 6291(27), with the exception of "Gas-fired instantaneous water heater," as codified at 10 CFR 430.2.

Generally, DOE defines a "water heater," consistent with EPCA's definition, as a product which utilizes oil, gas, or electricity to heat potable water for use outside the heater upon demand, including:

(a) Storage type units which heat and store water at a thermostatically controlled temperature, including gas storage water heaters with an input of 75,000 Btu per hour or less, oil storage water heaters with an input of 105,000 Btu per hour or less, and electric storage water heaters with an input of 12 kilowatts (kW) or less;

(b) Instantaneous type units which heat water but contain no more than one gallon of water per 4,000 Btu per hour of input, including gas instantaneous water heaters with an input of 200,000 Btu per hour or less, oil instantaneous water heaters with an input of 210,000 Btu per hour or less, and electric instantaneous water heaters with an input of 12 kilowatts or less; and

(c) Heat pump type units, with a maximum current rating of 24 amperes at a voltage no greater than 250 volts,[21] which are products designed to transfer thermal

[21] In the June 2023 TP Final Rule, DOE amended the definition of "commercial heat pump water heater" at 10 CFR 431.102 to align with the amperage and voltage requirements for consumer heat pump type units as specified in EPCA.

energy from one temperature level to a higher temperature level for the purpose of heating water, including all ancillary equipment such as fans, storage tanks, pumps, or controls necessary for the device to perform its function.

10 CFR 430.2; (42 U.S.C. 6291(27))

In addition, at 10 CFR 430.2, DOE further defines several specific categories of consumer water heaters as follows:

- "Electric instantaneous water heater" means a water heater that uses electricity as the energy source, has a nameplate input rating of 12 kW or less, and contains no more than one gallon of water per 4,000 Btu per hour of input.
- "Electric storage water heater" means a water heater that uses electricity as the energy source, has a nameplate input rating of 12 kW or less, and contains more than one gallon of water per 4,000 Btu per hour of input.
- "Gas-fired instantaneous water heater" means a water heater that uses gas as the main energy source, has a nameplate input rating less than 200,000 Btu per hour, and contains no more than one gallon of water per 4,000 Btu per hour of input.
- "Gas-fired storage water heater" means a water heater that uses gas as the main energy source, has a nameplate input rating of 75,000 Btu per hour or less, and contains more than one gallon of water per 4,000 Btu per hour of input.

- "Grid-enabled water heater" means an electric resistance water heater that—
    - Has a rated storage tank volume of more than 75 gallons;
    - Is manufactured on or after April 16, 2015;
    - Is equipped at the point of manufacture with an activation lock; and
    - Bears a permanent label applied by the manufacturer that—
        - Is made of material not adversely affected by water;
        - Is attached by means of non-water-soluble adhesive; and
        - Advises purchasers and end-users of the intended and appropriate use of the product with the following notice printed in 16.5 point Arial Narrow Bold font: "IMPORTANT INFORMATION: This water heater is intended only for use as part of an electric thermal storage or demand response program. It will not provide adequate hot water unless enrolled in such a program and activated by your utility company or another program operator. Confirm the availability of a program in your local area before purchasing or installing this product."
- "Oil-fired instantaneous water heater" means a water heater that uses oil as the main energy source, has a nameplate input rating of 210,000 Btu/h or less, and contains no more than one gallon of water per 4,000 Btu per hour of input.

- “Oil-fired storage water heater” means a water heater that uses oil as the main energy source, has a nameplate input rating of 105,000 Btu/h or less, and contains more than one gallon of water per 4,000 Btu per hour of input.

In the June 2023 Test Procedure Final Rule, DOE amended 10 CFR 430.2 (effective on July 21, 2023), adding the following definitions for circulating, low-temperature, and tabletop water heaters:

- “Circulating water heater” means an instantaneous or heat pump-type water heater that does not have an operational scheme in which the burner, heating element, or compressor initiates and/or terminates heating based on sensing flow; has a water temperature sensor located at the inlet or the outlet of the water heater or in a separate storage tank that is the primary means of initiating and terminating heating; and must be used in combination with a recirculating pump and either a separate storage tank or water circulation loop in order to achieve the water flow and temperature conditions recommended in the manufacturer’s installation and operation instructions.
- “Low-temperature water heater” means an electric instantaneous water heater that is not a circulating water heater and cannot deliver water at a temperature greater than or equal to the set point temperature specified in section 2.5 of appendix E to subpart B of this part when supplied with water at the supply water temperature specified in section 2.3 of appendix

E to subpart B of Part 430 and the flow rate specified in section 5.2.2.1 of appendix E to subpart B of Part 430.

- "Tabletop water heater" means a water heater in a rectangular box enclosure designed to slide into a kitchen countertop space with typical dimensions of 36 inches high, 25 inches deep, and 24 inches wide.

As stated in section I of this document, EPCA prescribed energy conservation standards for all consumer water heaters (*i.e.*, those that meet the definition of "water heater" above). For the purposes of this final rule, DOE is considering all consumer water heaters, as defined by EPCA, with the exception of "gas-fired instantaneous water heaters." This rulemaking does include consumer water heaters for which there are no current UEF-based standards codified at 10 CFR 430.32(d).

In the July 2023 NOPR, DOE responded to inquiries concerning coverage of hot water dispensing products (not to be confused with low-temperature electric instantaneous water heaters or point-of-use electric storage water heaters), which operate at less than 2 kW of power and generally provide water at temperatures between 160 °F and 210 °F for food preparation purposes. DOE stated that while it has the authority to set standards for products that meet the definition of a consumer water heater (42 U.S.C. 6292(a)(4)), this rulemaking is not currently considering standards for hot water dispensing products. 88 FR 49058, 49070.

Additionally, DOE received comments from stakeholders in response to the July 2023 NOPR regarding the scope and classification of circulating water heater as defined at 10 CFR 430.2 by the June 2023 TP Final Rule. DOE subsequently published an SNOPR on December 27, 2023 ("December 2023 SNOPR"), that discussed the comments received on this topic and proposed to amend the definition for "circulating water heater" to reclassify these products as storage-type water heaters. 88 FR 89330. In the December 2023 SNOPR, DOE proposed amending the definition of "circulating water heaters" to re-classify these products as storage-type water heaters. *Id*. After considering the comments on the December 2023 SNOPR, DOE is adopting its proposal to amend the definition for "circulating water heater" as it appears at 10 CFR 430.2 to reclassify these products as storage-type water heaters. The SNOPR comments received from stakeholders and DOE's responses, along with the definition of a "circulating water heater," are discussed in detail in section IV.A.1.a of this document. As a result of this reclassification, the scope of coverage for circulating water heaters is limited to those products which meet the statutory input rate limits for storage-type water heaters. Specifically, electric circulating water heaters must have a nameplate input rating of 12 kW or less, gas-fired circulating water heaters must have a nameplate input rating of 75,000 Btu/h or less, oil-fired circulating water heaters must have a nameplate input rating of 105,000 Btu/h or less, and heat pump circulating water heaters must have a maximum current rating of 24 amperes ("A") at a voltage no greater than 250 volts ("V"). Circulating water heaters that have input rates greater than these specifications would be considered commercial water heaters.

In response to the December 2023 SNOPR, BWC indicated that commercial circulating water heaters are not separately defined at 10 CFR 431.102 and the recent final rule regarding energy conservation standards for commercial water heaters[22] did not

[22] On October 6, 2023 the Department published a final rule amending standards for commercial water heating equipment, including commercial circulating water heaters. 88 FR 69686.

establish separate standards for circulating water heaters. BWC requested that DOE clarify how the provisions in the December 2023 SNOPR will impact commercial circulating water heaters if adopted. (BWC, No. 1413 at p. 2) A.O. Smith agreed with DOE's determination that circulating water heaters with input rates surpassing those defined for consumer storage water heaters as outlined in 10 CFR 430.2, should be classified as commercial water heaters. A.O. Smith suggested that DOE formalize this categorization by establishing definitions for commercial gas-fired circulating water heaters with input rates between 75,000 Btu/h and 200,000 Btu/h at 10 CFR 431.102. (A.O. Smith, No. 1411 at p. 2)

Rheem concluded that gas-fired circulating water heaters with input rates greater than 75,000 but less than or equal to 105,000 Btu/h could be categorized as residential-duty commercial water heating equipment,[23] and therefore could be subject to the energy conservation standards recently established in the commercial water heater equipment final rule. Rheem requested DOE confirm its understanding that the proposed definitions circulating water heaters would extend to residential-duty commercial water heaters. (Rheem, No. 1408 at p. 3)

The scope of this rulemaking pertains specifically to consumer water heaters, and the amended standards and definitions addressed herein do not apply to residential-duty commercial water heaters (which are commercial water heating equipment defined at 10 CFR 431.102). The definition of circulating water heater DOE is establishing at 10 CFR

[23] DOE defines residential-duty commercial gas-fired storage water heaters as commercial gas-fired storage water heaters that are not designed to provide outlet hot water at temperatures greater than 180 °F, do not have a rated input greater than 105,000 Btu/h, and do not have a rated storage volume greater than 120 gallons. (10 CFR 431.102)

430.2 will be supplemented by additional definitions for electric, gas-fired, and oil-fired circulating water heaters that specify input rate limits consistent with consumer water heaters. Circulating water heaters that exceed these input rates will be commercial water heaters and therefore are outside the scope of standards established in this rulemaking. DOE may consider addressing standards and test procedures for commercial circulating water heaters in a future rulemaking for commercial water heaters.

In response to the July 2023 NOPR, the Joint Advocacy Groups urged DOE to clarify that electric water heaters that can operate at inputs both above and below 12 kW must meet both the relevant consumer and commercial water heater standards. (Joint Advocacy Groups, No. 1165 at p. 8)

DOE is aware of certain "field-convertible" electric storage water heaters which can be sold with elements rated above 12 kW (*e.g.*, 12.1 kW), but the product is designed in a way that allows the user to change the elements to a lower input rate (*e.g.*, 6 kW). Field-convertible electric storage water heaters are, therefore, sold as commercial water heaters but can be converted into consumer water heaters.[24]

Consistent with its determinations in other rulemakings, DOE has concluded that if a product can be configured to meet either the commercial water heater definition or

[24] For example, Rheem offers a commercial electric water heater that is marketed for light-duty commercial applications. In certain storage volumes (*i.e.*, 66, 80, and 119.9 gallon models) the input rating as shipped from the manufacturer is only available at 12.1 kW which qualifies the product as a commercial water heater. However, the product literature states that this product is factory shipped with two 6.05 kW elements that operate simultaneously, but can be easily converted in field for non-simultaneous element operation. When converted, the input rating would be effectively 6.05 kW. This causes the product to meet the definition of a consumer water heater. For more information see: *https://s3.amazonaws.com/WebPartners/ProductDocuments/9A53AD9F-75C2-4E66-8967-1BAE91B17CAC.pdf* (Last accessed on Dec. 20, 2023)

the consumer water heater definition, then it must comply with the standards applicable to all types of product/equipment in which it can be configured. For example, in a recent final rule addressing convertible consumer refrigeration products, DOE specified that if a product is capable of operating with compartment temperatures as specified in multiple product category definitions (*i.e.*, a "convertible product"), the model must be tested and certified to each applicable product category. 88 FR 7840, 7843 (Feb. 7, 2023). Also, in a recent final rule addressing the test procedure for consumer boilers (which are a space-heating appliance that can often also be configured to provide domestic water heating), DOE determined that if a combination appliance meets the definition of a consumer boiler, the product must be tested per the boiler test procedure and demonstrate compliance with those standards. 88 FR 15510, 15515 (Mar. 13, 2023). Similarly, field-convertible electric storage water heaters are subject to the appendix E test procedure and the standards adopted by this final rule to the extent that they can be configured to meet the consumer water heater definition.

Uponor stated that other countries have generated domestic hot water via a heat exchanger connected to a hydronic mechanical system to improve water quality and energy efficiencies for decades. Uponor provided product literature from its technology offerings and requested clarification about how such products would be covered under DOE's standards. (Uponor, No. 606 at p. 1)

DOE reviewed the product literature cited by the commenter and found that the technology being referenced is an unfired heat exchange device which can couple hydronic piping to domestic hot water piping far downstream of the point of heat generation so that the heat exchange can occur in commercial high-rise buildings to produce domestic hot water using heat from the building's hydronic heating system. While DOE does not disagree that these technologies could improve high-rise building system efficiencies, the heat exchangers referenced by Uponor may be better characterized as heat recovery devices that function based on diverting excess heat to the domestic hot water supply and work in conjunction with the appliance providing the heat.

In response to the July 2023 NOPR, DOE received questions from BWC asking whether space-heating products that are capable of heating domestic hot water by means of an indirect water heater tank would be considered circulating water heaters. In response to the December 2023 SNOPR, Pickering provided comments raising concerns about the potential for evaluating efficiency gains if there is overlap between these types of systems and circulating water heaters.

Pickering commented that definitions that do not account for the array of equipment that is on the market or coming on the market, and that do not recognize the efficiency gains to be had with multiple pieces of equipment operating as a system, may limit choice and stifle innovation. Specifically, Pickering commented that the proposed definitions for circulating water heaters may be incompatible with or otherwise create regulatory impediments to air-to-water heat pumps that provide domestic hot water as an ancillary function to space conditioning. Pickering added that these combined systems can increase overall system efficiency over a more typical separated system, but that the proposed definitions mean that it may be difficult to quantity the efficiency of the domestic hot water function of a combined system specifically, and that they may not account for or accommodate the combinations of equipment (assembled on site) that produce domestic hot water in such a combined system. (Pickering, No. 1399 at pp. 1-3)

Pickering recommended DOE consider removing indirect tanks from the definition of conventional electric storage water heaters, refrain from setting water heater efficiency standards for heat pumps that produce domestic hot water as an ancillary function, clarify that gas-fueled heat pumps are not considered to be electric storage water heaters, and take a systems approach to energy efficiency for domestic hot water. (Pickering, No. 1399 at p. 3)

BWC requested that DOE provide answers to the following questions: 1) Are split-system heat pump products that provide space heating, as well as domestic hot water through an indirect unfired hot water storage tank ("UFHWST") classified as a circulating heat pump water heater, or instead as an air-to-water heat pump? 2) Would such a product need to be tested under the residential water heater test procedure, the air-to-water heat pump test procedure once such a procedure is created, or both? 3) Will such a product need to represent its efficiency using UEF or annualized fuel utilization efficiency, or both? (BWC, No. 1164 at pp. 11-12) While these questions pertain specifically to air-to-water heat pump appliances, DOE understands the need for general clarification regardless of the fuel type or technology.

Circulating water heaters circulate potable water through a heat exchanger: warm water from the stored volume of water enters the circulating water heater and exits after being heated to the setpoint temperature. By contrast, an indirect water heater uses the main furnace or boiler of a home to heat a fluid that is circulated through a heat exchanger in the storage tank.[25] An indirect water heater does not circulate the potable domestic hot water supply to and from the boiler (it is a separate heating fluid which circulates through the tank and boiler), therefore, DOE has determined that a boiler paired with an indirect water heater is not a circulating water heater.

Pickering also commented that the proposed definitions for circulating water heaters may be incompatible with or otherwise create regulatory impediments to solar thermal water heating systems. (Pickering, No. 1399 at p. 2)

DOE understands the commenter to be referring to solar water heating systems that circulate a hot heat transfer fluid between a solar heat collector and a heat exchanger inside a domestic hot water storage tank. Such a setup is parallel to an indirect-fired water heater: it is not the potable hot water that circulates between the heat source and the tank, it is an intermediate heat transfer fluid instead. As such, solar thermal water heating systems designed in this way do not constitute circulating water heaters.

This is in contrast to a boiler with a tankless coil (or a combination boiler-water heater). A tankless coil water heater provides hot water on demand without a tank, much like an instantaneous water heater. When a hot water faucet is turned on, water is heated as it flows through a heating coil or heat exchanger installed in a main furnace or boiler. In the tankless coil configuration, the domestic hot water supply does circulate through

[25] A diagram of an indirect water heater and further description of this design configuration is provided on DOE's website at: *www.energy.gov/energysaver/tankless-coil-and-indirect-water-heaters* (Last accessed: Oct. 30, 2023).

the boiler. However, these systems are typically flow-activated, and thus most do not meet the definition of a "circulating water heater," either.

BWC requested clarification on whether air-to-water heat pumps would be covered as both circulating water heaters and as hydronic heating system boilers, which are being discussed by the U.S. Environmental Protection Agency ("EPA") with regards to amendments to the consumer boiler specification. Specifically, BWC called attention to the potential overlap between the definition of circulating water heater and what the EPA is considering regulating as air-to-water (hydronic) heat pumps for space-heating in a potential revision or new specification for consumer boilers. BWC stated that both heat pump circulating water heaters and hydronic heat pumps are air-to-water heat pumps, and there would be an issue if multiple product definitions overlapped, thereby encompassing the same covered product within scope and subjecting it to two separate test procedures and efficiency standards. (BWC, No. 1164 at pp. 11-12)

There is currently no codified definition for an air-to-water hydronic heat pump used for space heating purposes. However, in a March 2023 final rule amending the test procedure for consumer boilers (the "March 2023 Boilers TP Final Rule"), DOE determined that hydronic heat pump appliances which meet the consumer boiler definition would be classified as consumer boilers. 88 FR 15510, 15516 (Mar. 13, 2023). However, the March 2023 Boilers TP Final Rule did not establish a test method for these hydronic heat pump boilers. *Id*. At this time, there is no Federal test procedure to determine the Annual Fuel Utilization Efficiency ("AFUE") of such a product, hence, there are also no AFUE requirements for these heat pumps. In the March 2023 Boilers TP Final Rule, DOE also stated that, to the extent that a combination space and water heating product meets the definition of electric boiler or low pressure steam or hot water boiler, it is subject to the boilers test procedure and energy conservation standards for consumer boilers at 10 CFR 430.32(e)(2), and must be tested and rated accordingly. *Id.* at 15515. Therefore, per DOE's test procedure requirements, if an air-to-water heat pump meets both the definition of a consumer boiler and a consumer water heater, then it must be tested to both test procedures, should the boilers test procedure be amended at a future date to include an applicable method of test. On June 5, 2023, EPA released a Discussion Guide[26] requesting information from stakeholders about a method of test for hydronic heat pump boiler systems. DOE will monitor the development of this method of test but notes that it is a draft specification that has not been released as of this final rule.

RVIA commented that based on the plain language of the consumer product statute, appliances designed specifically for use in a recreational vehicle ("RV") are exempted from new standards. RVIA urged DOE to continue to recognize the uniqueness of RVs and the importance of excluding specific component parts designed for RVs from new appliance standards. (RVIA, No. 1168 at p. 4)

The scope of this rulemaking excludes water heaters designed exclusively for RV applications because the definition of "consumer product" in EPCA excludes consumer products designed solely for use in recreational vehicles and other mobile equipment. (*See* 42 U.S.C. 6292(a)) In the market and technology assessment, DOE evaluated

[26] The Boilers Discussion Guide can be found online at: *www.energystar.gov/products/residential_boilers_specification* (Last accessed: Nov. 3, 2023).

certification data to ensure that the model information used throughout this rulemaking analysis aligned with the scope of coverage.

Section IV.A.1 of this document contains detailed discussion of the product classes analyzed in this final rule.

C. Test Procedure

EPCA sets forth generally applicable criteria and procedures for DOE's adoption and amendment of test procedures. (42 U.S.C. 6293) Manufacturers of covered products must use these test procedures to certify to DOE that their product complies with energy conservation standards and to quantify the efficiency of their product. DOE's current energy conservation standards for consumer water heaters are expressed in terms of UEF. (*See* 10 CFR 430.32(d).)

DOE most recently amended the test procedure for these products at appendix E in the consumer and residential-duty commercial water heater test procedure final rule published on June 21, 2023 ("June 2023 TP Final Rule") pursuant to the 7-year review requirement as specified by EPCA. (42 U.S.C. 6293(b)(1)(A) and 42 U.S.C. 6314(a)(1)(A)) In the June 2023 TP Final Rule, DOE added definitions and, where necessary, additional test procedure provisions for circulating water heaters, low-temperature water heaters, and tabletop water heaters, as well as provisions for high-temperature testing. However, DOE deferred the implementation of high-temperature testing provisions to this energy conservation standards rulemaking. 88 FR 40406, 40448. DOE also established effective storage volume as a metric and provided additional optional ambient test conditions for heat pump water heaters. *Id.* The test procedure for consumer water heaters incorporates by reference current versions of industry standards ASHRAE 41.1, ASHRAE 41.6, ASHRAE 118.2, ASTM D2156, and ASTM E97 and harmonizes various aspects of the test procedure with industry test procedures ASHRAE 118.2-2022 and NEEA Advanced Water Heating Specification v8.0. The amended test procedure established by the June 2023 TP Final Rule is mandatory for consumer water heater testing starting December 18, 2023, 180 days after publication, with the exception of certain provisions (*i.e.*, the new high temperature test method and the circulating water heater test method). For these specific provisions, compliance is mandatory on and after the compliance date of this final rule. (*See* Note at the beginning of appendix E).

D. Technological Feasibility

1. General

In each energy conservation standards rulemaking, DOE conducts a screening analysis based on information gathered on all current technology options and prototype designs that could improve the efficiency of the products or equipment that are the subject of the rulemaking. As the first step in such an analysis, DOE develops a list of technology options for consideration in consultation with manufacturers, design engineers, and other interested parties. DOE then determines which of those means for improving efficiency are technologically feasible. DOE considers technologies incorporated in commercially available products or in working prototypes to be technologically feasible. Sections 6(b)(3)(i) and 7(b)(1) of appendix A to 10 CFR part 430 subpart C ("Appendix A").

After DOE has determined that particular technology options are technologically feasible, it further evaluates each technology option in light of the following additional screening criteria: (1) practicability to manufacture, install, and service; (2) adverse impacts on product utility or availability; (3) adverse impacts on health or safety and (4) unique-pathway proprietary technologies. Section 7(b)(2)–(5) of the Appendix A. Section IV.B of this document discusses the results of the screening analysis for consumer water heaters, particularly the designs DOE considered, those it screened out, and those that are the basis for the standards considered in this rulemaking. For further details on the screening analysis for this rulemaking, *see* chapter 4 of the final rule TSD.

2. Maximum Technologically Feasible Levels

When DOE proposes to adopt a new or amended standard for a type or class of covered product, it must determine the maximum improvement in energy efficiency or maximum reduction in energy use that is technologically feasible for such product. (42 U.S.C. 6295(p)(1)) Accordingly, in the engineering analysis, DOE determined the maximum technologically feasible ("max-tech") improvements in energy efficiency for consumer water heaters, using the design parameters for the most efficient products available on the market or in working prototypes. The max-tech levels that DOE determined for this rulemaking are described in section IV.C of this final rule and in chapter 5 of the final rule TSD.

E. Energy Savings

1. Determination of Savings

For each trial standard level ("TSL"), DOE projected energy savings from application of the TSL to consumer water heaters purchased in the 30-year period that begins in the first full year of compliance with the amended standards (2030–2059).[27] The savings are measured over the entire lifetime of consumer water heaters purchased in the 30-year analysis period. DOE quantified the energy savings attributable to each TSL as the difference in energy consumption between each standards case and the no-new-standards case. The no-new-standards case represents a projection of energy consumption that reflects how the market for a product would likely evolve in the absence of amended energy conservation standards.

DOE used its national impact analysis ("NIA") spreadsheet models to estimate national energy savings ("NES") from potential amended standards for consumer water heaters. The NIA spreadsheet model (described in section IV.H of this document) calculates energy savings in terms of site energy, which is the energy directly consumed by products at the locations where they are used. For electricity, DOE reports national energy savings in terms of primary energy savings, which is the savings in the energy that is used to generate and transmit the site electricity. For natural gas, the primary energy savings are considered to be equal to the site energy savings. DOE also calculates NES in terms of full-fuel-cycle ("FFC") energy savings. The FFC metric includes the energy consumed in extracting, processing, and transporting primary fuels (*i.e.*, coal, natural gas,

[27] DOE also presents a sensitivity analysis that considers impacts for products shipped in a 9-year period.

petroleum fuels), and thus presents a more complete picture of the impacts of energy conservation standards.[28] DOE's approach is based on the calculation of an FFC multiplier for each of the energy types used by covered products or equipment. For more information on FFC energy savings, see section IV.H.2 of this document.

2. Significance of Savings

To adopt any new or amended standards for a covered product, DOE must determine that such action would result in significant energy savings. (42 U.S.C. 6295(o)(3)(B))

The significance of energy savings offered by a new or amended energy conservation standard cannot be determined without knowledge of the specific circumstances surrounding a given rulemaking.[29] For example, some covered products and equipment have most of their energy consumption occur during periods of peak energy demand. The impacts of these products on the energy infrastructure can be more pronounced than products with relatively constant demand. Accordingly, DOE evaluates the significance of energy savings on a case-by-case basis, taking into account the significance of cumulative FFC national energy savings, the cumulative FFC emissions reductions, and the need to confront the global climate crisis, among other factors.

As stated, the standard levels adopted in this final rule are projected to result in national energy savings of 17.6 quads, the equivalent of the primary annual energy use of

[28] The FFC metric is discussed in DOE's statement of policy and notice of policy amendment. 76 FR 51282 (Aug. 18, 2011), as amended at 77 FR 49701 (Aug. 17, 2012).
[29] The numeric threshold for determining the significance of energy savings established in a final rule published on Feb. 14, 2020 (85 FR 8626, 8670) was subsequently eliminated in a final rule published on Dec. 13, 2021 (86 FR 70892).

116 million homes. Based on the amount of FFC savings, the corresponding reduction in emissions, and the need to confront the global climate crisis, DOE has determined the energy savings from the standard levels adopted in this final rule are "significant" within the meaning of 42 U.S.C. 6295(o)(3)(B).

F. Economic Justification

1. Specific Criteria

As noted previously, EPCA provides seven factors to be evaluated in determining whether a potential energy conservation standard is economically justified. (42 U.S.C. 6295(o)(2)(B)(i)(I)(VII)) The following sections discuss how DOE has addressed each of those seven factors in this rulemaking.

a. Economic Impact on Manufacturers and Consumers

In determining the impacts of potential new or amended standards on manufacturers, DOE conducts an MIA, as discussed in section IV.J of this document. DOE first uses an annual cash-flow approach to determine the quantitative impacts. This step includes both a short-term assessment—based on the cost and capital requirements during the period between when a regulation is issued and when entities must comply with the regulation—and a long-term assessment over a 30-year period. The industry-wide impacts analyzed include (1) INPV, which values the industry on the basis of expected future cash flows; (2) cash flows by year; (3) changes in revenue and income; and (4) other measures of impact, as appropriate. Second, DOE analyzes and reports the impacts on different types of manufacturers, including impacts on small manufacturers.

Third, DOE considers the impact of standards on domestic manufacturer employment and manufacturing capacity, as well as the potential for standards to result in plant closures and loss of capital investment. Finally, DOE takes into account cumulative impacts of various DOE regulations and other regulatory requirements on manufacturers.

For individual consumers, measures of economic impact include the changes in LCC and PBP associated with new or amended standards. These measures are discussed further in the following section. For consumers in the aggregate, DOE also calculates the national net present value of the consumer costs and benefits expected to result from particular standards. DOE also evaluates the impacts of potential standards on identifiable subgroups of consumers that may be affected disproportionately by a standard.

b. Savings in Operating Costs Compared to Increase in Price (LCC and PBP)

EPCA requires DOE to consider the savings in operating costs throughout the estimated average life of the covered product in the type (or class) compared to any increase in the price of, or in the initial charges for, or maintenance expenses of, the covered product that are likely to result from a standard. (42 U.S.C. 6295(o)(2)(B)(i)(II)) DOE conducts this comparison in its LCC and PBP analysis.

The LCC is the sum of the purchase price of a product (including its installation) and the operating cost (including energy, maintenance, and repair expenditures) discounted over the lifetime of the product. The LCC analysis requires a variety of inputs, such as product prices, product energy consumption, energy prices, maintenance and repair costs, product lifetime, and discount rates appropriate for consumers. To account for uncertainty and variability in specific inputs, such as product lifetime and discount rate, DOE uses a distribution of values, with probabilities attached to each value.

The PBP is the estimated amount of time (in years) it takes consumers to recover the increased purchase cost (including installation) of a more-efficient product through lower operating costs. DOE calculates the PBP by dividing the change in purchase cost due to a more stringent standard by the change in annual operating cost for the year that standards are assumed to take effect.

For its LCC and PBP analysis, DOE assumes that consumers will purchase the covered products in the first year of compliance with new or amended standards. The LCC savings for the considered efficiency levels are calculated relative to the case that reflects projected market trends in the absence of new or amended standards. DOE's LCC and PBP analysis is discussed in further detail in section IV.F of this document.

c. Energy Savings

Although significant conservation of energy is a separate statutory requirement for adopting an energy conservation standard, EPCA requires DOE, in determining the economic justification of a standard, to consider the total projected energy savings that are expected to result directly from the standard. (42 U.S.C. 6295(o)(2)(B)(i)(III)) As discussed in section IV.H of this document, DOE uses the NIA spreadsheet models to project national energy savings.

d. Lessening of Utility or Performance of Products

In establishing product classes, and in evaluating design options and the impact of potential standard levels, DOE evaluates potential standards that would not lessen the utility or performance of the considered products. (42 U.S.C. 6295(o)(2)(B)(i)(IV)) Based on data available to DOE, the standards adopted in this document would not reduce the utility or performance of the products under consideration in this rulemaking.

e. Impact of Any Lessening of Competition

EPCA directs DOE to consider the impact of any lessening of competition, as determined in writing by the Attorney General, that is likely to result from a standard. (42 U.S.C. 6295(o)(2)(B)(i)(V)) It also directs the Attorney General to determine the impact, if any, of any lessening of competition likely to result from a standard and to transmit such determination to the Secretary within 60 days of the publication of a proposed rule, together with an analysis of the nature and extent of the impact. (42 U.S.C. 6295(o)(2)(B)(ii)) To assist the Department of Justice ("DOJ") in making such a determination, DOE transmitted copies of its proposed rule and the NOPR TSD to the Attorney General for review, with a request that the DOJ provide its determination on this issue. In its assessment letter responding to DOE, DOJ concluded that the proposed energy conservation standards for consumer water heaters are unlikely to substantially lessen competition. DOE is publishing the Attorney General's assessment at the end of this final rule.

In response to the July 2023 NOPR, NPGA, APGA, AGA, and Rinnai asserted that the standards proposed in the July 2023 NOPR would have a significant market effect, with manufacturers likely choosing to leave the market rather than expend the millions of dollars it would take to redesign their products and production especially in requiring condensing technology in order to be in compliance with the standards proposed. (NPGA, APGA, AGA, and Rinnai, No. 441 at p. 3)

Although commenters focus primarily on condensing technologies as it relates to GIWHs, which are not be amended in this final rule, DOE continued to look at the impact of competition as it relates to the other product classes for which DOE is adopting standards in this final rule. DOE does not expect that the adopted standard would significantly alter the level of concentration in the consumer water heater market. Additionally, DOJ stated, in a letter to DOE written in response to the July 2023 NOPR, that "we do not have an evidentiary basis to conclude that the proposed energy conservation standards for consumer water heaters are likely to substantially lessen competition." (*See* Attorney General's assessment at the end of this final rule). For this final rule, DOE reviewed up-to-date information on the consumer water heater models available on the U.S. market to ensure a comprehensive analysis of the current manufacturer landscape. In response to stakeholders' comments, DOE carefully reviewed product offerings of original equipment manufacturers ("OEMs") of gas-fired storage water heaters. DOE identified five OEMs of gas-fired storage water heaters that would be subject to more stringent standards under this rulemaking. Of the five OEMs identified, four OEMs currently manufacture gas-fired storage water heaters that meet the adopted TSL (EL 2 for gas-fired storage water heaters). Collectively, the four OEMs that already offer gas-fired storage water heaters that meet EL 2 account for approximately 95 percent of gas-fired storage water heater shipments.

f. Need for National Energy Conservation

DOE also considers the need for national energy and water conservation in determining whether a new or amended standard is economically justified. (42 U.S.C. 6295(o)(2)(B)(i)(VI)) The energy savings from the adopted standards are likely to provide improvements to the security and reliability of the Nation's energy system. Reductions in the demand for electricity also may result in reduced costs for maintaining the reliability of the Nation's electricity system. DOE conducts a utility impact analysis to estimate how standards may affect the Nation's needed power generation capacity, as discussed in section IV.M of this document.

DOE maintains that environmental and public health benefits associated with the more efficient use of energy are important to take into account when considering the need for national energy conservation. The adopted standards are likely to result in environmental benefits in the form of reduced emissions of air pollutants and greenhouse gases ("GHGs") associated with energy production and use. DOE conducts an emissions analysis to estimate how potential standards may affect these emissions, as discussed in section IV.K of this document; the estimated emissions impacts are reported in section V.B.6 of this document. DOE also estimates the economic value of emissions reductions resulting from the considered TSLs, as discussed in section IV.L of this document.

g. Other Factors

In determining whether an energy conservation standard is economically justified, DOE may consider any other factors that the Secretary deems to be relevant. (42 U.S.C.

6295(o)(2)(B)(i)(VII)) To the extent DOE identifies any relevant information regarding economic justification that does not fit into the other categories described previously, DOE could consider such information under "other factors."

2. Rebuttable Presumption

As set forth in 42 U.S.C. 6295(o)(2)(B)(iii), EPCA creates a rebuttable presumption that an energy conservation standard is economically justified if the additional cost to the consumer of a product that meets the standard is less than three times the value of the first year's energy savings resulting from the standard, as calculated under the applicable DOE test procedure. DOE's LCC and PBP analyses generate values used to calculate the effect potential amended energy conservation standards would have on the payback period for consumers. These analyses include, but are not limited to, the 3-year payback period contemplated under the rebuttable-presumption test. In addition, DOE routinely conducts an economic analysis that considers the full range of impacts to consumers, manufacturers, the Nation, and the environment, as required under 42 U.S.C. 6295(o)(2)(B)(i). The results of this analysis serve as the basis for DOE's evaluation of the economic justification for a potential standard level (thereby supporting or rebutting the results of any preliminary determination of economic justification). The rebuttable presumption payback calculation is discussed in section IV.F of this document.

IV. Methodology and Discussion of Related Comments

This section addresses the analyses DOE has performed for this rulemaking with regard to consumer water heaters. Separate subsections address each component of DOE's analyses.

DOE used several analytical tools to estimate the impact of the standards considered in this document. The first tool is a spreadsheet that calculates the LCC savings and PBP of potential amended or new energy conservation standards. The national impacts analysis uses a second spreadsheet set that provides shipments projections and calculates national energy savings and net present value of total consumer costs and savings expected to result from potential energy conservation standards. DOE uses the third spreadsheet tool, the Government Regulatory Impact Model ("GRIM"), to assess manufacturer impacts of potential standards. These three spreadsheet tools are available on the DOE website for this rulemaking: *www.regulations.gov/docket/EERE-2017-BT-STD-0019*. Additionally, DOE used output from the latest version of the Energy Information Administration's ("EIA's") *Annual Energy Outlook* ("*AEO*") for the emissions and utility impact analyses.

A. Market and Technology Assessment

DOE develops information in the market and technology assessment that provides an overall picture of the market for the products concerned, including the purpose of the products, the industry structure, manufacturers, market characteristics, and technologies used in the products. This activity includes both quantitative and qualitative assessments, based primarily on publicly available information. The subjects addressed in the market and technology assessment for this rulemaking include (1) a determination of the scope of the rulemaking and product classes, (2) manufacturers and industry structure, (3) existing efficiency programs, (4) shipments information, (5) market and industry trends, and (6) technologies or design options that could improve the energy efficiency of consumer water heaters. The key findings of DOE's market assessment are summarized in the following sections. *See* chapter 3 of the final rule TSD for further discussion of the market and technology assessment.

1. Product Classes

When evaluating and establishing energy conservation standards for a type (or class) of covered products, DOE divides covered products into product classes by the type of energy used, or by capacity or other performance-related features which other products within such type (or class) do not have and that justify differing standards. (42 U.S.C. 6295(q)) In making a determination whether a performance-related feature justifies a different standard, DOE must consider such factors as the utility of the feature to the consumer and other factors DOE determines are appropriate. *Id.*

EPCA, as amended by the National Appliance Energy Act (NAECA; Pub. L. 100-12), established initial energy conservation standards, expressed as EF, that were based on three product classes differentiated by fuel type: (1) gas-fired, (2) oil-fired, and (3) electric. (42 U.S.C. 6295(e)(1)) These standards applied to consumer water heaters manufactured on or after January 1, 1990.

DOE subsequently amended these EF standards twice, most recently in the April 2010 Final Rule, with which compliance was required starting on April 16, 2015. 75 FR

20112. In the April 2010 Final Rule, DOE further divided consumer water heaters into product classes based on fuel type (gas-fired, oil-fired, or electric), product type (storage, instantaneous, tabletop), storage volume, and input rate.

The Energy Efficiency Improvement Act of 2015 ("EEIA 2015") (Public Law 114-11), enacted on April 30, 2015, added a definition of "grid-enabled water heater" and a standard in terms of EF for such products to EPCA's energy conservation standards. (42 U.S.C. 6295(e)(6)(A)(ii)) DOE codified the definition for grid-enabled water heater and the associated energy conservation standards in a final rule published and effective on August 11, 2015. 80 FR 48004.

Most recently, the December 2016 Conversion Factor Final Rule, published and effective on December 29, 2016, translated the EF-based standards to UEF-based standards for certain classes of consumer water heaters, which are shown in Table IV.1. Although the classes of consumer water heaters with UEF-based standards have limitations on the stored volume, as discussed in that final rule, the standards established in EPCA do not place any limitation on the storage volume of consumer water heaters. Therefore, the original standards established by EPCA in terms of EF remain applicable to all products without UEF-based standards. 81 FR 96204, 96209–96211.

The 32 product classes covered in this final rule for which DOE has currently established UEF-based standards are summarized in Table IV.1. The product classes without UEF-based standards, for which EF-based standards from EPCA apply, are shown in Table IV.2.

Table IV.1 Consumer Water Heater Product Classes with Current UEF-Based Standards

Product Type Covered in this Final Rule	Rated Storage Volume and Input Rating (if applicable)	Draw Patterns
Gas-Fired Storage Water Heater	≥ 20 gal and ≤ 55 gal	Very Small Low Medium High
Gas-Fired Storage Water Heater	> 55 gal and ≤ 100 gal	Very Small Low Medium High
Oil-Fired Storage Water Heater	≤ 50 gal	Very Small Low Medium High
Electric Storage Water Heater	≥ 20 gal and ≤ 55 gal	Very Small Low Medium High
Electric Storage Water Heater	> 55 gal and ≤ 120 gal	Very Small Low Medium High
Tabletop Water Heater	≥ 20 gal and ≤ 120 gal	Very Small Low Medium High
Instantaneous Electric Water Heater	< 2 gal	Very Small Low Medium High
Grid-Enabled Water Heater	> 75 gal	Very Small Low Medium High

Table IV.2 Consumer Water Heater Product Classes without Current UEF-Based Standards

Product Class Covered in this Final Rule	Rated storage volume and input rating (if applicable)
Gas-fired Storage	< 20 gal
	> 100 gal
Oil-fired Storage	> 50 gal
Electric Storage	< 20 gal
	> 120 gal
Tabletop	< 20 gal
	> 120 gal*
Oil-fired Instantaneous	< 2gal
	≥ 2 gal
Electric Instantaneous	≥ 2 gal

* Note: products larger than 120 gallons are not possible to fit into the design description of a tabletop water heater, as discussed in section IV.A.1.f.iv.

The CA IOUs suggested that DOE reconsider its approach to setting minimum UEF standards for the water heaters formerly subject to EF standards. Citing the provisions in EPCA (42 U.S.C. 6295(q)(1)(B)), the CA IOUs stated that DOE must consider capacity, consumer utility, and other performance-related features when establishing separate product classes for different types of water heaters. The CA IOUs questioned whether converting an EF standard to a UEF standard should result in a new product class. The commenter urged DOE to immediately initiate a new rulemaking to address appropriate standards levels or the new product classes, if established. (CA IOUs, No. 1175 at p. 5)

In response to the CA IOUs, DOE originally established these product classes in the 2016 Conversion Factor Final Rule. 81 FR 96204, 96210. At this time, DOE does not have sufficient data to perform an analysis of costs versus benefits of subjecting these products to standards of the same stringency as the amended standards proposed in the July 2023 NOPR. While these products may not have performance-related “features” distinguishing them from currently covered products, these models come in different capacities than the products for which DOE has already established UEF-based standards.

As has been observed in DOE's teardown analyses and has been indicated by comments from manufacturers, the applicability of efficiency-improving design options is often predicated upon the size or capacity of the water heater; therefore, at this time, the capacities of these products do appear to justify separate standards. However, should future product designs demonstrate that the same efficiency-improving design options are equally as applicable for these capacities, DOE would consider the need for distinguishing these product classes by evaluating whether separate standards are justified for these capacities in a future standards rulemaking (*see* 42 U.S.C. 6295(q)(1)(B)).

a. Circulating Water Heaters

In the June 2023 TP Final Rule, DOE established a definition for "circulating water heater" in 10 CFR 430.2, and also established test procedures to determine the UEF of these types of water heaters. 88 FR 40406. In the July 2023 NOPR, DOE identified three potential classes of circulating water heater based on fuel type and input ratings derived from instantaneous water heater definitions in EPCA at 42 U.S.C. 6291(27), which are shown in 88 FR 49058, 49077.

Table IV.3, and proposed their addition to the definitions found at 10 CFR 430.2. 88 FR 49058, 49077.

Table IV.3 Proposed Classes of Circulating Water Heaters from July 2023 NOPR

Product Class	Characteristics
Gas-fired Circulating Water Heater	A circulating water heater with a nominal input of 200,000 Btu/h or less; contains no more than one gallon of water per 4,000 Btu/h of input
Oil-fired Circulating Water Heater	A circulating water heater with a nominal input of 210,000 Btu/h or less; contains no more than one gallon of water per 4,000 Btu/h of input
Electric Circulating Water Heater	A circulating water heater with an input of 12 kW or less; contains no more than one gallon of water per 4,000 Btu/h of input (including heat pump-only units with power inputs of no more than 24 A at 250 V)

As discussed in the June 2023 TP Final Rule, DOE had at that time determined that circulating water heaters with input ratings below 200,000 Btu/h (for gas-fired), 210,000 Btu/h (for oil-fired), or 12 kW (for electric) met the definitional criteria for instantaneous consumer water heaters. As such, these products were to be subject to the applicable energy conservation standards; however, DOE previously provided an enforcement policy for circulating water heaters.[30] Because an amended test procedure that includes new provisions for testing circulating water heaters was recently finalized in the June 2023 TP Final Rule, DOE proposed in the July 2023 NOPR to establish updated UEF standards that reflect the new test method and requested feedback on the proposed standards. In response to the July 2023 NOPR, DOE received comments that largely suggested that circulating water heaters are storage-type water heaters. As noted in section III.B, on December 27, 2023, therefore, DOE published the December 2023

[30] Prior to the June 2023 TP Final Rule, DOE became aware of gas-fired instantaneous water heaters meeting the definition of consumer water heaters which operated differently than those DOE had previously considered in test procedure rulemakings. On September 5, 2019, DOE issued an enforcement policy for consumer water heaters meeting the definition of gas-fired "circulating water heater" as described in said enforcement policy in which DOE stated that it would not seek civil penalties for failing to certify these products, or if these products failed to comply with applicable standards, on or before December 31, 2021. The June 2023 TP Final Rule has since addressed this issue by establishing test procedures to determine UEF ratings for circulating water heaters.

SNOPR that proposed to reclassify these products as configurations of storage-type water heaters, thus proposed that separate product classes for circulating water heaters are not required. 88 FR 89330.

A "circulating water heater" is currently defined at 10 CFR 430.2 as an "instantaneous or heat pump-type water heater that does not have an operational scheme in which the burner, heating element, or compressor initiates and/or terminates heating based on sensing flow; has a water temperature sensor located at the inlet or the outlet of the water heater or in a separate storage tank that is the primary means of initiating and terminating heating; and must be used in combination with a recirculating pump and either a separate storage tank or water circulation loop in order to achieve the water flow and temperature conditions recommended in the manufacturer's installation and operation instructions."

As described in the December 2023 SNOPR, circulating water heaters contain very little to no water on their own (*i.e.*, are "tankless"), but, as was determined in the June 2023 TP Final Rule, require a separate volume of water in order to function properly when installed in the field. In that rulemaking, circulating water heaters were designated as instantaneous-type water heaters because of the minimal storage volume contained within the product. However, comments received in response to the July 2023 NOPR led DOE to reevaluate circulating water heaters and propose in the December 2023 SNOPR to classify them as storage-type water heaters because they necessarily operate in tandem with a stored volume of water; hence, the circulating water heater and its separate tank or recirculation loop must be treated as one system. When considering the entire system—the circulating water heater plus the stored water volume required for its operation in the field—these water heaters are operationally very similar to storage-type water heaters and, as a result, DOE had tentatively determined that it is appropriate to classify them as such under its regulations. 88 FR 89330, 89333. The December 2023 SNOPR proposed the following revised definition for circulating water heaters:

"Circulating water heater means a water heater that does not have an operational scheme in which the burner, heating element, or compressor initiates and/or terminates heating based on sensing flow; has a water temperature sensor located at the inlet or the outlet of the water heater or in a separate storage tank that is the primary means of initiating and terminating heating; and must be used in combination with a recirculating pump to circulate water and either a separate storage tank or water circulation loop in order to achieve the water flow and temperature conditions recommended in the manufacturer's installation and operation instructions. Paired with a separate storage tank, a circulating water heater constitutes a storage-type water heater."

88 FR 89330, 89339.

CEC, BWC, NEEA, NYSERDA, ASAP et al., and A.O. Smith expressed support for DOE's tentative determination that circulating water heaters be considered storage-type water heaters and subject to the appropriate standards. (CEC, No. 1412 at pp. 1-2; BWC, No. 1413 at p. 1; NEEA, No. 1414 at p. 2; NYSERDA, No. 1406 at p. 2; ASAP et al., No. 1407 at pp. 1-2; A.O. Smith, No. 1411 at p. 2) NEEA and ASAP et al. noted that, compared to other storage-type water heaters, circulating water heaters do not provide any additional utility or performance-related features that would warrant a separate product class. (NEEA, No. 1414 at p. 2; ASAP et al., No. 1407 at pp. 1-2) NEEA and A.O. Smith commented that defining circulating water heaters as storage-type will address concerns regarding these products potentially being used as a circumvention pathway for more stringent storage-type standards. (NEEA, No. 1414 at p. 2; A.O. Smith, No. 1411 at p. 2) A.O. Smith added that this will provide more business certainty. (A.O. Smith, No. 1411 at p. 2)

DOE specifically requested comment and information on whether gas-fired circulating water heaters could offer the same utility as gas-fired instantaneous water heaters. 88 FR 89330, 89334. DOE sought to understand whether gas-fired circulating water heaters could be a potential loophole to gas-fired instantaneous water heater standards enforcement after receiving comments in response to the NOPR identifying such a possibility.

BWC agreed with DOE that gas-fired circulating water heaters would not be direct substitutes for gas-fired instantaneous water heaters, indicating that gas-fired circulating water heaters as defined in the December 2023 SNOPR are better suited towards providing large volumes of hot water in short periods of time and gas-fired instantaneous water heaters for lengthier periods of time. (BWC, No. 1413 at p. 3) Rheem supported DOE's tentative determination that circulating water heaters do not provide the same consumer utility as gas-fired instantaneous water heaters. Rheem added that though they do not currently exist on the market, the combination of the non-flow-activated operational scheme, storage tank or recirculation loop requirement, and input rate limits consistent with other storage-type water heaters present in DOE's definition ensures that any future gas-fired circulating water heaters would not serve as direct replacements for gas-fired instantaneous water heaters. (Rheem, No. 1408 at p. 2) A.O. Smith agreed with DOE's tentative determination that gas-fired circulating water heaters do not provide the same consumer utility as gas-fired instantaneous water heaters. (A.O. Smith, No. 1411 at p. 6) CEC noted that circulating water heaters provide different utilities from instantaneous water heaters and experience thermal standby losses more than a typical non-circulating storage water heater due to plumbing acting as a storage volume for a significant volume of hot water. (CEC, No. 1412 at p. 3) ASAP et al. agreed with DOE's tentative determination that gas-fired circulating water heaters do not provide the same consumer utility as gas-fired instantaneous water heaters due to the fact that gas-fired instantaneous water heaters utilize flow-activated control schemes and larger burners (compared to gas-fired circulating water heaters) in order to meet demand on a continuous basis, whereas gas-fired circulating water heaters must operate with a separate stored volume of hot water. (ASAP et al., No. 1407 at p. 2)

Rinnai agreed with DOE that gas-fired circulating water heaters do not provide the same utility as gas-fired instantaneous water heaters. Rinnai also stated that gas-fired circulating water heaters do not provide consumers with the same features, energy efficiency and reduced emissions benefits as gas-fired instantaneous water heaters at the proposed UEF levels. Rinnai reiterated its comments made in response to the July 2023 NOPR that UEFs of 0.80 to 0.81 result in increased energy savings and reduction of CO_2 emissions in comparison with the levels gas-fired circulating water heaters would be subject to as gas-fired storage water heaters. Thus, Rinnai arrived at a different conclusion from DOE and claimed that there is not a sufficient basis for allowing gas-fired circulating water heaters to be held to a lower UEF standard than other consumer products and requested that DOE instead establish the more stringent standards proposed in the July 2023 NOPR. (Rinnai, No. 1415 at pp. 1-2)

As discussed in section IV.A.1.c of this document, DOE has found sufficient justification in accordance with the provisions of EPCA to establish separate standards for storage-type and instantaneous-type water heaters.

Rheem, however, noted an additional concern that circulating water heaters can be paired with any size storage tank in the field, and that there is still a concern that circulating water heaters certified to a lower capacity energy conservation standard would be installed with higher capacity storage tanks where higher energy conservation standards would be required. Because of this, Rheem recommended DOE establish separate energy conservation standards for circulating water heaters, but at levels consistent with the higher capacity energy conservation standards. In its recommendation, Rheem showed that the standards equations for larger storage-type product classes (*i.e.*, gas-fired storage water heaters 55-100 gallons, and electric storage water heaters 55-120 gallons) would apply to both circulating water heaters and their analogous traditional storage-type water heaters. (Rheem, No. 1408 at pp. 2-3)

DOE understands Rheem to be suggesting that, in the case that a circulating water heater is designed and marketed to be paired with multiple volumes of storage tanks in the field, it is useful for the rating to reflect larger storage volumes. However, DOE notes that the size of the separate storage tank that the product is tested with (in accordance with section 4.10 of the test procedure) results in the effective storage volume of the circulating water heater, which, for most types of circulating water heaters will be 80 to

120 gallons. This already results in circulating water heaters being held to the same standards as larger storage water heaters. The only exception to this is electric heat pump circulating water heaters, which are paired with smaller tanks. Separate storage tank pairings are discussed further in section V.D.2 of this document. Additionally, the commenter does not provide evidence as to how different standards for circulating water heaters would be justified under the provisions of EPCA.

After reviewing these comments DOE has concluded that circulating water heaters do not have any characteristics which justify separate standards under the provisions of EPCA at 42 U.S.C. 6295(q)(1). DOE has determined not to create separate product classes for circulating water heaters.

To accomplish this, in the December 2023 SNOPR DOE had proposed an addition to the definition that stated, "Paired with a separate storage tank, a circulating water heater constitutes a storage-type water heater." 88 FR 89330, 89335.

Multiple stakeholders raised concern that DOE's proposed revised definition for "circulating water heater" seemingly implies that circulating water heaters are only storage-type water heaters if they are paired with a separate storage tank. These commenters—NEEA, ASAP et al., the CA IOUs, CEC, A.O. Smith and NYSERDA—all indicated that circulating water heaters paired with a circulating loop also constitute storage-type water heaters. (NEEA, No. 1414 at p. 3; ASAP et al., No. 1407 at p. 2; CA IOUs, No. 1409 at pp. 1-2; CEC, No. 1412 at p. 2; A.O. Smith, No. 1411 at pp. 4-5; NYSERDA, No. 1406 at p. 2)

NEEA requested that DOE define circulating water heaters as constituting storage-type water heaters regardless of the configuration in which they are sold or installed. (NEEA, No. 1414 at p. 3) ASAP et al. encouraged DOE to clarify the proposed definition for circulating water heaters so that it is clear all circulating water heaters, whether paired with a separate storage tank or recirculation loop, would be considered storage-type water heaters. (ASAP et al., No. 1407 at p. 2)

The CA IOUs also stated that excluding mention of circulation loops would be inconsistent with the earlier definitional requirements indicating that they must be paired with either a separate storage tank or a water circulation loop and recommend that DOE modify the definition as "Paired with a separate storage tank or circulation loop, a circulating water heater constitutes a storage-type water heater." (CA IOUs, No. 1409 at pp. 1-2)

CEC provided similar statements, adding that the exclusion of pairings with water circulation loops may become a loophole exploited by manufacturers. CEC recommended that DOE modify the definition to simply state that "a circulating water heater constitutes a storage-type water heater" to avoid potential misreading. (CEC, No. 1412 at p. 2)

A.O. Smith recommended DOE remove the phrase “paired with” from the statement “paired with a separate storage tank a circulating water heater constitutes a storage-type water heater” in the definition for circulating water heater to avoid implying that only circulating water heaters that come with a manufacturer-specified or supplied tank would be considered circulating water heaters. In place of this phrasing, A.O. Smith suggested DOE incorporate the definition for a "water heater requiring a storage tank" currently outlined in section 1.9 of appendix E to Subpart B into 430.2 and reference this definition in the circulating water heater definition to ensure clarity. A.O. Smith commented that, given the input capacity limits placed on circulating water heaters in their respective definitions, a recirculation loop without the use of a storage tank is unlikely to be an applicable configuration in the residential context. Therefore, A.O. Smith recommended DOE remove the term "either" and the phrase "or water recirculation loop" from the circulating water heater definition proposed in the December 2023 SNOPR. (A.O. Smith, No. 1411 at pp. 4-5)

NYSERDA recommended that DOE update the definition for circulating water heater to read as follows: "When paired with a separate storage tank or as part of a water circulation loop, a circulating water heater constitutes a storage-type water heater". (NYSERDA, No. 1406 at p. 2)

In response to these requests for further clarification, DOE agrees with most commenters that circulating water heaters would constitute storage water heaters whether they are paired with a tank or a recirculation loop. The loop serves to store hot water in pipes instead of in a tank. In both cases, the product does not function properly unless the hot water can be maintained outside of the water heater prior to delivery at a fixture.

While A.O. Smith suggested that a circulating water heater be defined as a "water heater requiring a storage tank," this is not necessarily reflective of field usage to the extent that it can be used to define the product at 10 CFR 430.2. Numerous other comments indicate that a circulating water heater can also function with a recirculation loop. DOE has found examples of gas-fired instantaneous water heaters with input rates that modulate as low as 15,000 Btu/h and can be outfitted with recirculation loops in residential homes. While these specific products are *not* circulating water heaters because they have flow-activated control schemes and do not explicitly require a separate volume of stored hot water to function, they do demonstrate that it is possible for gas-fired products with input rates lower than 75,000 Btu/h to be used in conjunction with a recirculation loop and no tank.

Circulating water heaters are treated as "water heaters requiring a storage tank" in appendix E for the purpose of conducting the test procedure because they are not sold with a tank. The appendix E test procedure refers to "water heaters requiring a storage tank" in section 1.19 order to provide instruction on how to set up such a water heater with a representative volume of stored water. Therefore, DOE is not amending 10 CFR 430.2 to define a "water heater requiring a storage tank" because this terminology has limited application to the test setup instructions in appendix E only. DOE is also not incorporating this terminology in the definition of "circulating water heater" so as not to contradict how these products can be designed, marketed, and used in the field.

After considering the suggestions provided by interested parties, DOE is amending the definition of "circulating water heater" at 10 CFR 430.2 to read as:

Circulating water heater means a water heater that does not have an operational scheme in which the burner, heating element, or compressor initiates and/or terminates heating based on sensing flow; has a water temperature sensor located at the inlet or the outlet of the water heater or in a separate storage tank that is the primary means of initiating and terminating heating; and must be used in combination with a recirculating pump to circulate water and either a separate storage tank or water circulation loop in order to achieve the water flow and temperature conditions recommended in the manufacturer's installation and operation instructions. A circulating water heater constitutes a storage-type water heater.

The December 2023 SNOPR had also proposed to amend the definitions of the three different fuel types of circulating water heater to align with the re-classification of these products as storage water heaters. 88 FR 89330, 89339.

CA IOUs stated that specifying the volume of stored water per 4,000 Btu/h of input in these definitions is unnecessary because circulating water heaters are already defined as storage-type water heaters and recommended that DOE remove this requirement from the definitions of electric, gas-fired and oil-fired circulating water heaters as proposed in the December 2023 SNOPR. (CA IOUs, No. 1409 at p. 2)

DOE also agrees with the CA IOUs' suggestion to revise the definitions for the different types of circulating water heaters. As discussed in section III.B, these additional definitions serve mainly to clarify the input rate cutoffs to distinguish these products from commercial water heaters. DOE is amending these definitions to read as:

Electric circulating water heater means a circulating water heater with an input of 12 kW or less (including heat pump-only units with power inputs of no more than 24 A at 250 V).

Gas-fired circulating water heater means a circulating water heater with a nominal input of 75,000 Btu/h or less.

Oil-fired circulating water heater means a circulating water heater with a nominal input of 105,000 Btu/h or less.

In the December 2023 SNOPR DOE requested comment on what the implications to industry might be if circulating water heaters were to be treated as storage water heaters. 88 FR 89330, 89335. In response, several commenters agreed that DOE's analysis for amended standards of storage-type water heaters is still representative if circulating water heaters are included in these product classes.

CEC agreed with DOE that the definition of circulating water heater as proposed in the December 2023 SNOPR would not change the results of the life-cycle cost, national impact, and other downstream analyses, stating that the proposed changes would not cause DOE's analysis to become unrepresentative and agreeing that no additional analysis is necessary. (CEC, No. 1412 at p. 2) The CA IOUs stated that there are few to no shipments of consumer water heaters meeting the definition of "circulating water heater" as proposed in the December 2023 SNOPR. CA IOUs stated that DOE may therefore maintain its July 2023 NOPR analyses with respect to storage-type water heaters and apply the associated proposed standards to circulating water heaters. (CA IOUs, No. 1409 at p. 1) NYSERDA and ASAP et al. stated their agreement with DOE's assessment that, because DOE has not identified consumer water heaters on the U.S. market that qualify as circulating water heaters, analytical results from the July 2023 NOPR remain representative and do not need to be updated due to changes proposed in the December 2023 SNOPR. (NYSERDA, No. 1406 at p. 2; ASAP et al., No. 1407 at p. 3) ASAP et al. added that, if introduced, circulating water heaters would likely have similar cost and usage characteristics to existing storage-type consumer water heaters. (ASAP et al., No. 1407 at p. 3)

Rinnai, however, requested that DOE clarify the justification for amending the definition of products that do not currently exist on the market. (Rinnai, No. 1415 at p. 1) BWC agreed with DOE that circulating water heaters as defined in the June 2023 TP Final Rule are not deployed in residential applications. (BWC, No. 1413 at p. 1) BWC agreed with DOE that there are no consumer products that meet the definition of "circulating water heater" as proposed in the December 2023 SNOPR and requested that DOE clarify how it determined that these products would have similar cost and use profiles as storage-type water heaters. (BWC, No. 1413 at p. 2)

In the December 2023 SNOPR the Department had erroneously stated that there are no longer heat pump circulating water heaters available on the market (*see* 88 FR 89330, 89333) due to changes in a manufacturer's website. Product literature for these models exists and has been added to the docket for this rulemaking. In addition to stakeholder comments, this literature demonstrates the use of these products in a manner similar to storage-type water heaters. Shipments of these products, though they are fewer than those of traditional storage-type water heaters, are not zero. These products are included in historical data on heat pump water heater shipments as they would meet efficiency level 1 for small electric storage water heaters. Hence DOE's analysis does include circulating heat pump water heaters as storage-type water heaters.

b. Low-Temperature Water Heaters

As stated previously in section III.B of this document, in the June 2023 TP Final Rule, DOE established the following definition for "low-temperature water heater" in 10 CFR 430.2:

"Low-temperature water heater" means an electric instantaneous water heater that is not a circulating water heater and cannot deliver water at a temperature greater than or equal to the set point temperature specified in section 2.5 of appendix E to subpart B of this part when supplied with water at the supply water temperature specified in section 2.3 of appendix E to subpart B of Part 430 and the flow rate specified in section 5.2.2.1 of appendix E to subpart B of Part 430.

DOE also established test procedures to determine the UEF of these types of water heaters. 88 FR 40406. Regarding low-temperature water heaters, DOE notes that they are covered as electric instantaneous water heaters. As discussed in section IV.C of this document, DOE is not considering updated standards for electric instantaneous water heaters in this rulemaking because it was unable to determine technologies associated with increased efficiencies in these products. Therefore, although low-temperature water heaters are tested in a slightly different manner from other electric instantaneous water heaters, DOE is maintaining low-temperature water heaters within the broader electric instantaneous water heater product class as proposed in the July 2023 NOPR and is not establishing a separate class for them.

c. Storage-Type and Instantaneous-Type Product Classes

In the March 2022 Preliminary Analysis, DOE addressed comments received in response to the May 2020 RFI that suggested that DOE should consider eliminating the separate product classes for instantaneous water heaters. For the preliminary analysis, DOE analyzed separate classes for instantaneous water heaters, but sought feedback from stakeholders on whether storage-type and instantaneous-type water heater product classes should be combined. (See section 2.3 of the preliminary TSD.)

In response to the March 2022 Preliminary Analysis, DOE received comments indicating that storage and instantaneous product classes should not be combined because each type of product provides unique utility to consumers and combining their product classes would lead to UEF standards that are not technologically feasible. DOE tentatively agreed with these comments, which were addressed in the July 2023 NOPR, and maintained separate product classes for storage and instantaneous water heaters for its analyses and proposed standards. 88 FR 49058, 49078.

In response to the July 2023 NOPR, BWC agreed with DOE's tentative determination to maintain separate product classes for instantaneous-type and storage-type water heaters because they offer distinct utilities to consumers in both their designs and capabilities. (BWC, No. 1164 at p. 14) Rheem also agreed with DOE's tentative determination to maintain separate product classes for storage-type and instantaneous-type water heaters given that these water heaters have different utilities and operational characteristics which necessitate separate consideration. (Rheem, No. 1177 at p. 11) However, Rheem noted that the proposed standards for electric instantaneous water heaters with 2 or more gallons of rated storage volume are significantly higher than the standards proposed for very small electric storage water heaters despite these products all having similar under-sink or commercial applications. (Rheem, No. 1177 at pp. 13–14) Rheem also requested clarification on whether rated or effective storage volume should be used when determining the storage-type and instantaneous-type water heater classification. (Rheem, No. 1177 at p. 2)

NEEA stated that, while it does not disagree with DOE's conclusion to create separate standards for gas-fired storage and gas-fired instantaneous water heaters, standby energy losses should not be considered in a determination of product class as they do not constitute a performance-related feature. NEEA noted that in DOE's decision to set separate product classes for storage and tankless water heaters, DOE stated that "storage water heaters have associated standby energy losses that instantaneous water heaters do not." (NEEA, No. 1199 at p. 10)

AWHI, however, urged DOE to investigate combining gas-fired instantaneous and gas-fired storage water heater categories in a future rulemaking such that the same minimum UEF requirements would apply to both product classes. (AWHI, No. 1036 at pp. 3–4)

After reviewing the comments received on the July 2023 NOPR, DOE has determined that different product classes and standards for storage and instantaneous water heaters remain necessary at this time, and DOE is not combining them in this rulemaking. As stated in the July 2023 NOPR, storage and instantaneous water heaters offer distinct utilities to a consumer. For example, instantaneous water heaters provide a continuous supply of hot water, up to the maximum flow rate, while storage water heaters are often better suited to handle large initial demands for hot water as opposed to continuous draws. 88 FR 49058, 49078. These products are, therefore, designed differently to suit these different needs. As a result of the design differences (*i.e.*, the storage of hot water in storage-type water heaters), storage-type water heaters incur standby losses to the surrounding ambient air.

In response to Rheem, DOE notes that although electric instantaneous water heaters with 2 or more gallons of rated storage volume and very small electric storage water heaters may be used for many of the same under-sink-type applications, each still offers distinct utility to the consumer. Per their definitions at 10 CFR 430.2, electric instantaneous water heaters will necessarily have a higher input rate to volume ratio, and thus will be capable of operating on a more continuous basis than very small electric storage water heaters within the flow rate expectations of these applications. DOE expects these products to have design differences because the scope of coverage is limited to products with electric input rates no greater than 12 kW (*see* section III.B of this document); therefore, electric instantaneous water heaters cannot contain more than approximately 10 gallons of hot water,[31] whereas very small electric storage water heaters can contain up to 20 gallons.

In response to NEEA, DOE does not consider standby losses to be a performance-related feature; rather, the performance-related features are as previously described and

[31] 12 kW is approximately 41,000 Btu/h. Instantaneous-type water heaters contain no more than one gallon of water per 4,000 Btu/h of input, resulting in a maximum of about 10 gallons for an electric instantaneous water heater with 12 kW of input.

the standby losses create the difference in energy consumption between storage-type and instantaneous-type water heaters that justifies different standard levels for the two types of products. In accordance with 42 U.S.C. 6295(q), DOE has concluded that separate standards for storage-type and instantaneous-type water heaters are justified not only because these types offer distinct utilities to the consumer, but also because the design necessary to provide this utility (*i.e.*, a stored volume of water for storage-type water heaters) affects the UEF rating.

EPCA defines instantaneous-type water heaters as units which heat water but contain no more than one gallon of water per 4,000 Btu per hour of input. (42 U.S.C. 6291(27)(B)) Based on the specific use of the term "contain," the rated storage volume, which reflects the amount of water that can be contained, should be used when determining the storage-type and instantaneous-type water heater classification. For circulating water heaters, which operate in a system that contains a stored volume of hot water, this is the rated storage volume of the separate storage tank (*see* section IV.A.1.a of this document).

d. Gas-Fired Water Heaters

Gas-fired water heaters operate by burning fuel to generate heat, which is then transferred from the products of combustion (*i.e.*, flue gases) to the water using a heat exchanger before the flue gases are expelled through venting to the outside. Regardless of efficiency, gas-fired water heaters operate in the same manner, by transferring heat to potable water for use within residences. Any combustion heat not transferred to the water is lost to the environment as waste heat, primarily through the exhaust venting.

The difference between high-efficiency water heaters and low-efficiency water heaters is the amount of heat that is lost to the environment. Condensing gas-fired water heaters are able to transfer more heat from the flue gases to the water, which results in less heat being lost to the environment. As a result, flue gases exhausted from a condensing gas-fired water heater are typically less than 130 °F, while flue gases exhausted to the environment from a non-condensing gas-fired storage water heater may be in the 300-400 °F range or even higher. Condensing gas-fired water heaters are able to extract more heat due to improved heat exchanger designs.

For example, A.O. Smith notes that their high-efficiency condensing gas storage water heaters "are built similarly to standard [non-condensing] gas tank water heaters with some modifications for higher efficiency and performance."[32] More specifically, A.O. Smith notes that their condensing models "are built with [a] helical internal heat exchanger that keeps combustion gasses in the tank longer to transfer more heat into the water, increasing efficiency and reducing operating cost."[33]

On December 29, 2021, DOE published a final interpretive rule ("December 2021 Venting Interpretive Final Rule") reinstating its long-standing interpretation that the heat exchanger technology and associated venting used to supply heated air or hot water is not a performance-related "feature" that provides a distinct consumer utility under EPCA. 86 FR 73947. Throughout this rulemaking, some commenters have urged DOE to reconsider the conclusions reached in the December 2021 Venting Interpretive Final

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[32] *See* A.O. Smith's Info Center on Gas Tank High Efficiency Water Heaters, available at *www.hotwater.com/info-center/gas-water-heaters/gas-tank-high-efficiency.html (*last accessed Apr. 3, 2024).
[33] *Id.*

Rule, and in the July 2023 NOPR, DOE considered these comments but again concluded that heat exchanger technology and venting do not constitute any of the characteristics upon which DOE has the authority to establish separate product classes under EPCA. 88 FR 49058, 49079.

i. General Comments

Earthjustice supported DOE's tentative determination in the NOPR that separate product classes for condensing and non-condensing products are not warranted, and stated that this is consistent with DOE's determinations in the December 2021 Venting Interpretive Rule. (Earthjustice, No. 1189 at pp. 2–3)

In response to comments that DOE should establish separate product classes for condensing and non-condensing gas-fired water heaters, DOE notes that when evaluating and establishing energy conservation standards, DOE is required to establish product classes based on: (1) the type of energy used; and (2) capacity or other performance-related feature which other products within such type (or class) do not have and that DOE determines justify a different standard. In making a determination of whether a performance-related feature justifies a different standard, DOE must consider factors such as the utility to the consumer of the feature and other factors DOE determines are appropriate. (42 U.S.C. 6295(q))

ii. Performance-Related Feature under 42 U.S.C. 6295(q)(1)(B)

DOE received several comments on whether non-condensing technology should be considered a performance-related feature for the purpose of establishing a separate product class under 42 U.S.C. 6295(q). For example, Rinnai stated that, pursuant to section 6295(q) of EPCA, DOE is required to issue higher or lower energy conservation standards for non-condensing and condensing gas-fired instantaneous water heaters because the products have distinct capacities and performance-related features that provide consumer utility and justify separate standards. (Rinnai, No. 1186 at p. 15) Rinnai asserted that DOE's finding in the July 2023 NOPR that non-condensing technology does not constitute a performance-related feature as prescribed by EPCA at 42 U.S.C. 6295(q)(1) exceeds DOE's authority because it errs in limiting the analysis to non-condensing technology, ignoring features associated with non-condensing technology such as ease of installation and reduced installation cost, and because it interprets "utility" too narrowly by only considering the impact the technology has on consumer's operation of or interaction with the appliance. (Rinnai, No. 1186 at pp. 12–14) Similarly, TPPF commented that DOE should set a separate standard for condensing water heaters because, according to TPPF, a non-condensing water heater serves a separate consumer utility because it is more compact, easier to install, and requires less maintenance. TPPF asserted that the consumer utility of a design is not limited to that which is accessible to the layperson or based upon the consumer's operation of or interaction with the product, even the ease of installation of a non-condensing gas-fired instantaneous water heater should be considered a consumer utility. (TPPF, No. 1153 at pp. 3–4)

ONE Gas asserted that minimizing installed cost is a distinct product utility. (ONE Gas, No. 1200 at p. 5) ONE Gas asserted that the availability of products that can serve as a "drop-in" replacement for consumers who already have non-condensing products without modifications to the installation space is a consumer utility. ONE Gas also asserted that the ability of "drop-in" replacements to restore water heating ability without delays associated with switching to other products is a consumer utility. (ONE Gas, No. 1200 at p. 5) ONE Gas stated that the December 2021 Venting Interpretive Final Rule did not consider the technical and economic burdens of installation when it concluded that product classes based on combustion system types (*i.e.*, non-condensing and condensing) did not provide distinct customer utility among combustion appliances. (ONE Gas, No. 1200 at p. 6) ONE Gas reiterated its comments that DOE's determination that condensing/non-condensing combustion and power/atmospheric venting do not provide unique customer utility is unreasonable and that DOE is required to separately consider minimum energy standards for "covered products that [have] two or more subcategories" under EPCA at 42 U.S.C. 6295(q)(1). (ONE Gas, No. 1200 at p. 8)

With respect to commenters' statements that venting associated with non-condensing technology itself is a performance-related feature that justifies a separate product class, DOE first notes that venting, like a gas burner or heat exchanger, is one of the basic components found in every gas-fired water heater (whether condensing or noncondensing). As such, assuming venting is a performance-related feature, it is a feature that all gas-fired water heaters possess. As a result, it cannot be the basis for a product class. *See* 42 U.S.C. 6295(q)(1)(B). Thus, in order to meet the product class requirements in 42 U.S.C. 6295(q)(1)(B), these commenters are requesting DOE determine that a specific type of venting is a capacity or other performance-related feature.

A specific venting technology—including non-condensing venting—is not a "capacity or other performance related feature" under 42 U.S.C. 6295(q)((1)(B). As discussed in the December 2021 final interpretive rule, DOE has concluded that performance-related features are those that a consumer would be aware of and would recognize as providing additional benefits during operation of the covered product or equipment. 86 FR 73947, 73955.

DOE also notes that almost every component of a covered product could be broken down further by any of a number of factors. For example, heat exchangers, which are used in a variety of covered products, could be divided further by geometry or material; refrigerator compressors could be further divided by single-speed or variable-speed; and air-conditioning refrigerants could be further divided by global warming potential. As a general matter, energy conservation standards save energy by removing the least-efficient technologies and designs from the market. For example, DOE set energy conservation standards for furnace fans at a level that effectively eliminated permanent split capacitor (PSC) motors from several product classes, but which could be met by brushless permanent magnet (BPM) motors, which are more efficient. 79 FR 38130 (July 3, 2014). As another example, DOE set energy conservation standards for microwave oven standby mode and off mode at a level that effectively eliminated the use of linear power supplies, but which could be met by switch-mode power supplies, which exhibit significantly lower standby mode and off mode power consumption. 78 FR 36316 (June 17, 2013). The energy-saving purposes of EPCA would be completely frustrated if DOE were required to set standards that maintain less-energy-efficient covered products and equipment in the market based simply on the fact that they use a specific type of less efficient heat exchanger, motor, power supply, *etc*.

In this rule and many others, DOE has considered whether the purported "feature" provides additional performance benefits to the consumer during operation. Using the previous example of furnace fan motors, if an interested person had wanted to preserve furnace fans with PSC motors in the market, they would have had to show that furnace fans with PSC motors offered some additional performance benefit during operation as compared to furnace fans with BPM motors. Refrigerator-freezers, on the other hand, are an example of where DOE determined that a specific type of performance-related feature offered additional performance benefit during operation. Some refrigerator-freezers have automatic icemakers. Additionally, some automatic icemakers offer through-the-door ice service, which provides consumers with an additional benefit during operation. As such, DOE further divided refrigerator-freezers into product classes based on the specific type of automatic icemaker (*i.e.*, whether the automatic icemaker offers through-the-door ice service). *See* 10 CFR 430.32(a).

After reviewing comments from stakeholders provided in this rulemaking, DOE has concluded that commenters have not pointed to any additional performance benefits during operation offered by non-condensing water heaters that use non-condensing venting as compared to water heaters that use other types of venting. Instead, these commenters generally cite compatibility with existing venting (*i.e.*, convenience of installation) and other economic considerations as reasons why non-condensing venting should be considered a performance-related feature for the purposes of EPCA's unavailability provision. To be sure, DOE considers installation costs in determining whether a standard is economically justified. The costs of installing condensing venting may, in certain installations, be substantial, and DOE accounts for such costs in its analysis. See section IV.F.2. But such installation costs are not a "capacity or other performance-related feature" for purposes of section 6295(q).

DOE has determined, based on its own research as well as information presented in stakeholder comments, that differences in cost or complexity of installation between different methods of venting (*e.g.*, a condensing water heater versus a non-condensing water heater) do not make specific methods of venting a performance-related feature under 42 U.S.C. 6295(o)(4), so as to justify separating the products/equipment into different product/equipment classes under 42 U.S.C. 6295(q)(1). 86 FR 73947, 73951 (Dec. 29, 2021).

iii. Whether Stakeholders Have Shown by a Preponderance of Evidence that Standards Would Result in Unavailability

DOE received public comments in reference to the "unavailability provision" found in EPCA, 42 U.S.C. 6295(o)(4), contending that if the proposed amended standard for GIWH were adopted, it would eliminate non-condensing GIWH from the market. DOE is not summarizing or responding to these comments in this notice, as DOE continues to consider these comments in informing DOE's decision on amended energy conservation standards for GIWH.

iv. Proper Treatment of Economic Considerations

According to NPGA, APGA, AGA, and Rinnai, the proposed UEF requirements for gas-fired storage water heaters would require new venting requirements and other additional equipment even if the adopted standards did not require condensing gas-fired storage water heaters. Based on these proposed UEF requirements, NPGA, APGA, AGA, and Rinnai asserted that DOE failed to understand the market for water heaters and what differentiates consumer decisions, apparent in its discussion of product classes in the July 2023 NOPR. NPGA, APGA, AGA, and Rinnai further asserted that DOE's failure to separate product classes based on relevant features preferred by consumers shows a fundamental market misunderstanding, questioning DOE's capacity to regulate the market. According to NPGA, APGA, and Rinnai, DOE continues to strain to show that the consumer gains no utility from features associated with condensing and non-condensing products, insisting that the design and operation of the unit "does not provide any utility to the consumer that is accessible to the layperson, which is based upon the consumer's operation of or interaction with the appliance;" however, these commenters stated, these design and installation issues are certainly accessible to the consumer when choosing the appliance. (NPGA, APGA, AGA, and Rinnai, No. 441 at pp. 2–3)

NPGA, APGA, AGA, Rinnai, and TPPF commented that DOE does not capture what differentiates consumer decisions to purchase non-condensing over condensing water heaters. DOE recognizes, however, that purchase price, installation cost, and maintenance cost—factors which some commenters suggested could be "features" of non-condensing models that lead some consumer to pick these models over condensing models—are relevant to consumer decision-making. Accordingly, DOE has treated those variables as inputs to evaluate the costs and benefits to consumers of standards requiring differing technologies. But as stated previously, those factors, while relevant to consumer decision-making and DOE's standard setting, are not "features" for purpose of sections 6295(o)(4) or (q)(1)(B). As stated in the December 2021 Venting Interpretive Final Rule, the "features" DOE considers separately pertain to those aspects of the appliance with which the consumer interacts during the operation of the product (*i.e.*, when the product is providing its "useful output") and the utility derived from those features during normal operation. 86 FR 73947, 73955. The installation and purchase decision factors mentioned by commenters do not affect the performance of the water heater and how a consumer uses it, but instead impact the cost of owning and operating one.

Because DOE views the issues discussed here to be matters of cost, the Department finds it appropriate under the statute to address these issues through the rulemaking's economic analysis. 86 FR 73947, 73951 (Dec. 29, 2021). This interpretation is consistent with EPCA's requirement for a separate analysis of economic justification for the adoption of any new or amended energy conservation standard (*see* 42 U.S.C. 6295(o)(2)–(3); 42 U.S.C. 6313(a)(6)(A)–(C); 42 U.S.C. 6316(a)). These costs are addressed in the LCC in section IV.F.

v. Comparison to Ventless Clothes Dryers

Rinnai noted that, in the case of ventless clothes dryers, DOE recognized consumer costs associated with venting as a basis for establishing separate product classes. (Rinnai, No. 1186 at p. 11)

In response to Rinnai's discussion of ventless clothes dryers, DOE notes that venting in the case of clothes dryers is different from venting of gas-fired appliances, where combustion gases must be exhausted outside of the home, and these differences are outlined in the December 2021 Venting Interpretative Final Rule.

Venting for clothes dryers refers to the method of removal of evaporated moisture from the cabinet space. Vented clothes dryers exhaust this evaporated moisture from the cabinet outside of the home whereas ventless clothes dryers instead use a closed-loop system with an internal condenser to remove the evaporated moisture from the heated air. In the TSD accompanying a 2011 direct final rule pertaining to residential clothes dryers, DOE explained that ventless clothes dryers can be installed where vented dryers would be precluded due to restrictions preventing any sort of vent from being installed, and thus the Department noted that how a clothes dryer is vented is not simply an issue of initial costs or a consumer choosing one product over another.[34] As discussed in the December 2021 Venting Interpretive Final Rule, unlike consumers of ventless dryers, consumers facing the prospect of replacing a non-condensing water heater with a condensing water heater do have options available to either modify existing venting or install a new venting system to accommodate a condensing product, or to install a feasible alternative to have heated air or water provided (*i.e.*, an electric appliance); but in all cases, the consumer would not be precluded from having access to heated water, a result which is distinctly different from the one at issue in the ventless clothes dryers example. 86 FR 73947, 73957. Condensing gas-fired water heaters can still be installed in buildings where non-

[34] Technical Support Document: Energy Efficiency Program for Consumer Products and Commercial and Industrial Equipment: Residential Clothes Dryers and Room Air Conditioners, pp. 3-6 (Available at: www.regulations.gov/document?D=EERE-2007-BT-STD-0010-0053).

condensing gas-fired water heaters currently are. This is because, unlike the case of clothes dryers, both non-condensing and condensing gas-fired water heaters use a vent—the difference in installation is in the type of venting material and its cost.

vi. Conclusion

For the reasons discussed in this section and in the December 2021 Final Interpretive Rule, DOE continues to find that there is no basis for altering the Department's approach regarding the establishment of product classes for gas-fired water heaters for this rulemaking.

e. Very Large Gas-fired Storage Water Heaters

A.O. Smith identified that a product class for > 100 gallon gas-fired storage water heaters with a non-condensing efficiency level is likely to incentivize the circumvention of current condensing standards for 55–100 gallon gas-fired storage water heaters and residential-duty commercial gas-fired storage water heaters. (A.O. Smith, No. 1182 at p. 14) NYSERDA commented that a non-condensing-level standard for gas-fired storage water heaters > 100 gallons would result in market confusion and the possibility of circumventing residential-duty commercial water heater standards, because residential-duty commercial gas-fired storage water heaters may typically only be just over the 75,000 Btu/h input rate limit and could easily be converted to consumer water heaters. (NYSERDA, No. 1192 at p. 6)

DOE notes that the non-condensing level for > 100 gallon gas-fired storage water heaters is simply a crosswalk of existing standards, and, as discussed in section IV.C.2, DOE did not evaluate more stringent standards for this product class in this rulemaking.

However, DOE understands the concerns from these stakeholders and may consider evaluating amended standards for these product classes in a future rulemaking.

f. Electric Storage Water Heaters

In response to the March 2022 Preliminary Analysis, DOE received comments requesting that DOE establish separate product classes for heat pump electric storage water heaters and electric resistance storage water heaters, citing concern with expanding heat pump-level standards for electric storage water heaters. DOE responded to these comments in the July 2023 NOPR, tentatively determining that the conclusions reached in the April 2010 Final Rule that separate classes are not justified (*see* 75 FR 20112, 20135) remain valid and that heat pump electric storage water heaters and electric resistance storage water heaters do not warrant separate product classes as they do not exhibit any unique performance-related features. 88 FR 49058, 49079–49080.

In response to the July 2023 NOPR, DOE received additional comments regarding the creation of separate product classes for heat pump electric storage water heaters and electric resistance storage water heaters. EEI asserted that DOE should create separate product classes or require lower efficiency levels for electric resistance storage water heaters rather than maintaining these technologies in the same classes with heat pump water heaters, as this would allow newer technologies at more economic price points a chance to meaningfully compete in the marketplace and would, in turn, support the Administration’s climate and clean energy goals. EEI stated that the proposed standards would cause a significant increase in efficiency for existing electric resistance storage water heaters. (EEI, No. 1198 at pp. 2–3) Earthjustice, however, stated that separate product classes for heat pump and electric resistance storage water heaters are not warranted, as the NOPR correctly determines. Earthjustice added, specifically, that separate product classes would not be justifiable under EPCA because heat pump and electric resistance water heaters provide equivalent service to the end-user. (Earthjustice, No. 1189 at pp. 1–2)

DOE agrees with EarthJustice and maintains its longstanding position, outlined most recently in the July 2023 NOPR, that separate product classes for heat pump and electric resistance water heaters are not warranted under EPCA. DOE establishes separate product classes based on two criteria: (1) fuel source; and (2) whether a type of product offers a unique capacity or other performance-related feature that justifies a different standard. (*See* 42 U.S.C. 6295(q)(1))

Heat pump electric storage water heaters and electric resistance water heaters both use electricity as the fuel source. 88 FR 49058, 49079-49080. They both offer similar delivery capacities, and DOE has not identified any unique performance-related features offered by either heat pump electric storage water heaters or electric resistance storage water heaters. *Id*. DOE considers performance-related features to be those aspects of the appliance with which the consumer interacts during operation of the product. The technology used to heat the water, heat pump or electric resistance, is not something a consumer would interact with during operation of the water heater. Therefore, DOE has maintained both heat pump and electric resistance technologies within the electric storage water heater classes in this rulemaking analysis, consistent with its approach in the April 2010 Final Rule.

i. Configurations of Electric Water Heaters

In response to the December 2023 SNOPR, A.O. Smith requested clarification as to what test procedure provisions apply to electric resistance booster water heaters that meet the definition of a “water heater requiring a storage tank” but not of a “circulating water heater”. A.O. Smith added that the June 2023 TP Final Rule preamble seems to indicate that electric resistance booster water heaters are to be tested to section 4.10 of appendix E, but that the heading for section 4.10 indicates the section is intended for circulating water heaters and does not include provisions for electric resistance booster water heaters. A.O. Smith commented that electric resistance booster water heaters and circulating water heaters both should be considered as “water heater requiring a storage tank” and recommended that the same test procedure apply to both. A.O. Smith recommended DOE implement this approach by establishing a definition for electric resistance booster water heaters and updating section 4.10 of appendix E to include provisions for testing electric resistance booster water heaters. (A.O. Smith, No. 1411 at p. 6)

In response to A.O. Smith, DOE notes that this section provides a description of electric water heater design examples and how they should be tested and classified for the applicable standards. An electric instantaneous water heater product that is designed to operate in tandem with a storage tank but not circulate the water between itself and the tank is not a circulating water heater because it does not meet the definitional criteria "must be used in combination with a recirculating pump to circulate water." A.O. Smith suggested that this type of add-on product might qualify as a "water heater requiring a storage tank" per section 1.19 of appendix E; however, DOE does not find this to necessarily be true. Appendix E defines a "Water Heater Requiring a Storage Tank" in part as a water heater without a storage tank that cannot meet the requirements of sections 2 and 5 of this appendix without the use of a storage water heater or unfired hot water storage tank. However, section 5.2.2.1 specifies that, for flow-activated water heaters, if the water heater is not capable of providing the discharge temperature specified in section 2.5 of appendix E when the flow rate is 1.7 gallons ± 0.25 gallons per minute, then adjust the flow rate as necessary to achieve the specified discharge water temperature. Based on these requirements, electric resistance booster water heaters would indeed be able to be tested in accordance with appendix E without the use of a storage water heater or separate storage tank.

A.O. Smith said that it agreed with DOE's clarifications in the December 2023 SNOPR which classify all split-system heat pump water heaters, regardless of whether or not they include a tank, as electric storage water heaters. (A.O. Smith, No. 1411 at p. 3-4)

To offer additional clarity on how different electric water heaters would be regulated as a result of this final rule, Table IV.4 shows the distinguishing characteristics of circulating water heaters, split-system heat pump water heaters, and other water heaters that operate in tandem with a separate tank but are instantaneous-type.

A split-system heat pump water heater is defined in section 1.13 of appendix E and reads, "Split-system heat pump water heater means a heat pump-type water heater in which at least the compressor, which may be installed outdoors, is separate from the storage tank" (therefore, a split-system heat pump water heater is supplied with a storage tank). These designs are discussed more in the following subsection of this document. The definition of a circulating water heater is provided in section IV.A.1.a, and the key distinction between a heat pump circulating water heater and a split-system heat pump water heater is that a circulating water heater is not sold with a tank (but must be paired with a tank or other stored volume of water in the field to operate), whereas a split system heat pump water heater is sold with a tank. Although heat pump circulating water heaters and split system heat pump water heaters are functionally very similar when installed in the field, they are differentiated in DOE's regulations due to differences in the test methods, which are outlined in Table IV.4. The definition of a low-temperature water heater is provided in section IV.A.1.b, and these units are instantaneous-type (they do not include circulating water heaters).

Table IV.4 Electric Water Heater Design Examples and Classifications

No.	Design Example	Product Category	Test Method	Determining Applicable Standard
1	A heat pump module that is not sold with a hot water storage tank or auxiliary electric storage water heater, but must be paired with one in the field to operate. The heat pump intakes water and outputs it at an elevated temperature using a recirculation pump. The heat pump only activates when a temperature sensor indicates that a separately stored quantity of water cools below an activation temperature.	*Electric storage water heater.* This design meets the definition of a *circulating water heater*, which is a storage-type water heater. It heats a remotely-stored quantity of water and returns the hot water to that stored water, but is sold without a storage tank.	Test with a separate storage tank per section 4.10 of appendix E. Because this is a heat pump, the tank pairing would be a 30 ± 5 gallon small electric storage water heater. Test conditions for the tank and heat pump are to be in accordance with section 2.2.2 of appendix E.	Per section 6.3.1.1 of appendix E, the effective storage volume is the volume of the tank (30 ± 5 gallons). If the first-hour rating is below 51 gallons, the product is a small electric storage water heater.
2	A heat pump module sold with a storage tank (which may or may not include backup heating elements).	*Electric storage water heater.* This design meets the definition of a *split-*	Test with the tank that is sold with the heat pump. Test conditions for the	The effective storage volume is determined based on the provisions of section

	The system is designed to circulate water between the heat pump and the tank and could contain the temperature sensors for the heat pump in the stored water in the tank.	*system heat pump water heater*, which is a storage-type water heater because it contains more than one gallon of water per 4,000 Btu per hour of input.	tank and heat pump are to be in accordance with section 2.2.2 of appendix E.	6.3.1.1 of appendix E.
3	A heat pump module sold with a storage tank (which may or may not include backup heating elements) having a specific design to accommodate the temperature sensor for the heat pump and the refrigerant lines. The system is designed with refrigerant lines connecting the heat pump to the tank and provide the heat transfer (rather than circulating water between the heat pump and tank as in design example #2 in this table).	*Electric storage water heater.* This design meets the definition of *a split-system heat pump water heater*, which is a storage-type water heater because it contains more than one gallon of water per 4,000 Btu per hour of input.	Test with the tank that is sold with the heat pump. Test conditions for the tank and heat pump are to be in accordance with section 2.2.2 of appendix E.	The effective storage volume is determined based on the provisions of section 6.3.1.1 of appendix E.
4	An electric resistance heating module that is not sold with a hot water storage tank, but must be paired with one in the field to operate. The electric resistance module intakes water and outputs it at an elevated temperature using a recirculation pump. The electric resistance element(s) only activate when a temperature sensor indicates that a separately stored quantity of water cools below an activation temperature.	*Electric storage water heater.* This design meets the definition of a *circulating water heater*, which is a storage-type water heater. It heats a remotely-stored quantity of water and returns the hot water to that stored water, but is sold without a storage tank.	Test with a separate storage tank per section 4.10 of appendix E. Because this is an electric resistance heater, the tank pairing would be an 80-120 gallon unfired hot water storage tank.	Per section 6.3.1.1 of appendix E, the effective storage volume is the volume of the tank (80-120 gallons).*
5	An electric resistance heating module that identical to design example # 4 in this table, but is sold with a storage tank.	*Electric storage water heater.* This design contains more than one gallon of water per 4,000 Btu per hour of input.	Test with the tank that is sold with the heater.	The effective storage volume is determined based on the provisions of section 6.3.1.1 of appendix E.
6	An electric resistance heater that operates in tandem with a separate storage tank, but is not sold with a tank. It activates during draws if the temperature of the water delivered by the tank falls below an activation	*Electric instantaneous water heater.* This design contains less than one gallon of water per 4,000 Btu per hour of input. While it is typically	Test as a stand-alone water heater (*i.e.*, without a storage tank). If it cannot raise water from the required supply temperature to a nominal delivery	The draw pattern is determined based on maximum GPM determined by testing the design per section 5.2.2.1 of appendix E.

	temperature. The heater intakes water from the tank and outputs it at an elevated temperature directly to the distribution system and not back to the tank.	installed with a separate tank that it is not sold with, it does not circulate hot water with the tank and does not need to a recirculation pump to operate. The design is flow-activated by the draw and not thermostatically activated by the temperature inside the tank to replenish the hot water storage.	temperature of 125 °F (*i.e.*, meets the definition of a *low-temperature water heater*), test per the instructions in section 5.2.2.1 of appendix E.	

* Note that, because the standards for 55 to 120 gallon electric storage water heaters correspond to heat pump efficiencies, such a product would not be compliant with current or amended standards.

The same concepts would apply for any other fuel type (*e.g.*, gas or oil).

ii. Plug-In and Split-System Heat Pump Electric Storage Water Heaters

DOE received comments in response to the March 2022 Preliminary Analysis recommending that DOE create a separate product class for split-system and plug-in (120-volt) heat pump water heaters. Commenters cited their utility in installation scenarios unable to be met by other heat pump water heaters. DOE responded to these comments in the July 2023 NOPR stating that, while plug-in heat pump water heaters were not considered in the March 2022 Preliminary Analysis because they were not commercially available in the United States at the time, DOE did not have enough information to determine whether a higher or lower efficiency standard would be justified. DOE also stated that it had not identified any unique performance-related features that would warrant a separate product class for split-system heat pump water heaters or plug-in heat pump water heaters. 88 FR 49058, 49080.

Responding to the July 2023 NOPR, Rheem supported DOE's tentative determination not to assign separate product classes to 120-volt heat pump water heaters, noting that its 120-volt design configurations are able to meet the proposed standards. Rheem also stated that there is no need to amend the test procedure for 120-volt heat pump water heaters at this time. (Rheem, No. 1177 at p. 8) A.O. Smith, however, recommended that DOE separate 120-volt heat pump water heaters into their own product class and align the efficiency levels for this product class to ENERGY STAR® Version 5.0. A.O. Smith added that 120-volt heat pump water heaters are relatively new designs and are limited in capacity due to the absence of backup electric resistance elements (because the product must operate at a lower voltage of 120 volts as opposed to conventional 240-volt products). To ensure consumer satisfaction, A.O. Smith stated, these products will tend to favor maintaining higher FHRs at the detriment of UEF. (A.O. Smith, No. 1182, pp. 15–16)

BWC also supported DOE's tentative determination not to create a separate product class for 120-volt heat pump water heaters. BWC stated it does not believe that otherwise identical electric products differentiated only by their operating voltage meet the criteria for establishing separate product classes; the commenter asserted that the voltage of the product does not cause the consumer to interact with the product differently; not does it enhance the utility being provided directly to the consumer by the product. (BWC, No. 1164 at p. 14)

Based on its review of the few models of 120-volt heat pump water heaters that have been released at the time of this final rule, DOE agrees with BWC in that it has not identified any unique consumer utility provided by the 120-volt plug-in configuration.

As discussed in the assessment of benefits and burdens of each TSL (section V.C.1 of this document), DOE has determined that the amended standards adopted in this final rule will not significantly inhibit the future development of 120-volt heat pump water heaters. Further details of 120-volt heat pump water heaters are provided in DOE's market and technology assessment in chapter 3 of the final rule TSD.

In addition to 120-volt plug-in heat pump water heaters, split-system heat pump water heaters are another possible configuration of electric storage water heater.

A.O. Smith stated that commercially available split-system heat pump water heaters fall under two main categories: refrigerant-split systems (for electric storage water heaters) and water-split or "monoblock" systems (for electric circulating water heaters). (A.O. Smith, No. 1182 at p. 16)

As discussed in section IV.A.1.a of this document, DOE has determined that circulating water heaters are a configuration of storage-type water heater. Therefore, refrigerant-split systems and water-split systems must meet the same the standards adopted under this final rule. As was tentatively determined in the July 2023 NOPR, DOE has determined not to create a separate product class for split-system heat pump water heaters. Split-system heat pump water heaters use the same fuel source—electricity—as other electric storage water heaters. DOE also has not identified any unique performance-related features offered by split-system heat pump water heaters that would warrant a separate product class consideration at this time. And, as DOE stated previously, the type of technology used to heat the water, in this case a split-system heat pump, is not something a consumer would interact with during operation of the water heater.

In the December 2023 SNOPR DOE explained that treating circulating water heaters as storage water heaters was parallel to how split-system heat pump water heaters are treated: a heat pump module and a separate storage tank, which, altogether, are treated as a storage-type water heater. 88 FR 89330, 89333. Specifically, DOE wrote that these products "have long been considered to be electric storage water heaters." *Id*.

Pickering noted that while most air-to-water heat pumps are electric, systems using natural gas or propane as the fuel source are emerging. Pickering added that the emergence of such technologies is not in agreement with DOE's statement that heat pump water heaters "have long been considered to be electric storage water heaters". (Pickering, No. 1399 at p. 2)

DOE agrees with Pickering that the statement in the December 2023 SNOPR implicitly was only referring to electric heat pumps. Split-system heat pump water heaters that do not rely on electricity as the main fuel source would not be electric storage water heaters. For example, split-system heat pump water heaters that are gas-fired would be considered gas-fired storage water heaters. Gas-fired heat pump water heaters are addressed in section IV.B.1 of this document.

iii. Grid-Enabled Water Heaters

Grid-enabled water heaters are a specific type of electric storage water heater with separate standards established by EPCA. (*See* 42 U.S.C. 6295I(6)(A)(ii), also discussed in section III.B of this document). The statutory definition of a grid-enabled water heater describes its characteristics as a product which must be activated when enrolled with a utility, but it does not specifically define what connected features the product must have once enrolled. In the July 2023 NOPR, DOE did not propose to define the connected features because DOE had not found it necessary at the time to further define connectivity.

SkyCentrics and TVA requested that DOE include a requirement for an open standard communication port such as EcoPort (CTA-2045) or equivalent to be added to the product requirements for all electric storage water heaters with a storage volume larger than or equal to 32 gallons. (TVA, No. 978 at pp. 1–2; SkyCentrics, No. 1191 at p. 1) TVA added that there are many water heater models with the port currently on or soon to be on the market, and stated that DOE can help promote this port as a national standard, helping OEMs benefit from volume production and reducing the cost of production by reducing SKUs with models that can be sold nationally. (TVA, No. 978 at pp. 1–2) AWHI also urged DOE to require CTA-2045 EcoPort in new electric storage water heaters, stating that industry partners would be ready for compliance with CTA 2045-B Level 2 as of July 1, 2025. (AWHI, No. 1036 at pp. 4–6)

DOE is maintaining its determination from the July 2023 NOPR not to adopt any specific requirements to define connectivity in this rulemaking. With respect to grid-enabled water heaters, the scope of this product class is defined by EPCA, which does not posit any specific design requirements for the demand-response communication protocol. While DOE recognizes that industry may benefit from standardization of the communication protocols, demand-response technology is not known to be a design option to improve efficiency of the product over an average use cycle (*see* chapter 3 of the final rule TSD, which discusses DOE's technology assessment); hence, it was not considered in the design pathway for compliance with more stringent standards. While EPCA establishes the authority for DOE to amend energy conservation standards for consumer water heaters, it does not directly grant DOE the authority to establish prescriptive design requirements for consumer water heaters, particularly as it relates to a requirement that would not directly impact the measured energy efficiency as measured by the DOE test procedure. Instead, the ongoing work by the EPA's ENERGY STAR program is expected to promote the standardization of demand-response technology. Specifically, ENERGY STAR's version 5.0 specification contains criteria for meeting the connected product designation, which references the CTA-2045 and OpenADR protocols.

Additionally, in the July 2023 NOPR, DOE did not propose to amend standards for grid-enabled water heaters because there remains uncertainty as to whether these products can achieve higher UEF values with added insulation (reduced standby losses being the main pathway towards higher efficiency because grid-enabled water heaters are statutorily defined as having electric resistance heating). 88 FR 49058, 49086.

NRECA and ECSC supported DOE's proposed retention of existing standards for grid-enabled water heaters, adding that these larger water heaters remain an important load-control tool for their member electric cooperatives. (NRECA, No. 1127 at pp. 2, 10; ECSC, No. 1185 at p. 2) NYSERDA also supported DOE's proposals regarding grid-enabled water heaters and stated that there is additional opportunity to address demand-response functionality in a future rulemaking. (NYSERDA, No. 1192 at p. 4)

CEC, however, urged DOE to reevaluate its conclusion that heat pump technology is not applicable as a technology option for grid-enabled water heaters, adding that although they are statutorily defined as "electric resistance water heaters" (*see* 42 U.S.C. 6295(e)(6)(A)(ii)), this definition does not preclude additional technologies, such as heat pumps. Therefore, CEC stated, the vast majority of hybrid grid-enabled water heaters employing both heat pump and electric resistance technologies would meet the statutory definition of grid-enabled water heater. (CEC, No. 1173 at pp. 11–12) The CA IOUs recommended that DOE amend standards for grid-enabled water heaters to be equivalent in stringency to those of other electric storage water heaters in a future rulemaking because these products directly compete with heat pump water heaters between 55 and 120 gallons. The CA IOUs also requested that DOE comply with the terms of the 2015 legislation creating the grid-enabled water heater product type and release the two market data reports described in 42 U.S.C. 6295(e)(6)(D)(i). (CA IOUs, No. 1175 at p. 5)

At this time, DOE is not aware of any commercially available heat pump water heaters that also meet the statutory definition of a grid-enabled water heater. Grid-enabled water heaters constitute an entirely separate product class, defined at 42 U.S.C. 6295(e)(6)(A)(ii) and must have a rated storage volume of more than 75 gallons. Not all demand-response water heaters meet the definition of a grid-enabled water heater. While DOE agrees that it is technologically feasible for grid-enabled water heaters to employ heat pumps to increase efficiency, such a product does not exist on the market. Manufacturers of certain models of heat pump water heaters in the electric storage water heater category, however, have certified these units' demand-response capabilities (which can be incorporated in water heaters outside of the grid-enabled product class) to ENERGY STAR, which indicates that heat pump innovation for grid-connected products can continue to occur in the absence of heat pump-level standards for grid-enabled water heaters; thus, it is unclear whether heat pump-level standards for grid-enabled water heaters would result in significant energy savings considering that shipments of electric storage water heaters dwarf those of grid-enabled water heaters today.[35] In other words, consumers seeking demand-response capabilities with heat pump technology could be more likely to seek an electric storage water heater with a communication module than a grid-enabled water heater. DOE may further evaluate the potential for more stringent standards for grid-enabled water heaters in a future rulemaking addressing energy conservation standards for consumer water heaters.

Rheem noted that EPCA (42 U.S.C. 6295(e)(6)(A)(ii)(I)) specifically defines grid-enabled water heaters on the basis that such a product "has a rated storage tank volume of more than 75 gallons," and that DOE would be misaligning the scope of coverage of the grid-enabled water heater product classes if it were to define these classes as being greater than 75 gallons of effective storage volume. (Rheem, No. 1177 at p. 3)

DOE agrees with Rheem and will maintain the current product class definition for grid-enabled water heaters, which is based on rated storage volume rather than effective storage volume. However, as discussed in section V.D.1.f of this document, DOE is adopting amendments to the appendix E test procedure that will effectively exempt grid-

[35] DOE included an assessment of grid-enabled water heaters in the March 2022 Preliminary Analysis. In shipments estimates, it was approximated that there were about 15 thousand shipments of grid-enabled water heaters in 2021, compared to 3.8 million shipments of other electric storage water heaters. See the NIA spreadsheet to the March 2022 Preliminary Analysis, docketed as Document No. EERE-2017-BT-STD-0019-0024 and available online at *www.regulations.gov/document/EERE-2017-BT-STD-0019-0024*.

enabled water heaters from the high temperature test method such that there is not likely to be any appreciable difference between the two volume metrics as they pertain to standards for grid-enabled water heaters. Therefore, the standards for grid-enabled water heaters will apply to products with rated storage volume greater than 75 gallons instead of an effective storage volume greater than 75 gallons, and this change from the July 2023 NOPR proposal is not expected to have any impact on the results of DOE's analysis or the scope of applicability of standards.

AHRI indicated that there is an additional backsliding concern for grid-enabled water heaters but did not elaborate on details of the concern. The commenter claimed that grid-enabled water heaters will not work correctly unless they are enrolled in a utility program and noted that DOE is collecting information to determine if these products are used properly in the field. (AHRI, No. 1167 at p. 5)

DOE has not identified any backsliding concerns for grid-enabled water heaters. Furthermore, maintaining the definition of this product class in terms of rated storage volume will mean no change to the standards for grid-enabled water heaters and therefore, no backsliding will occur. Regarding the functionality of grid-enabled water heaters, DOE agrees that grid-enabled water heaters will not function correctly unless enrolled in a utility program. Specifically, per 42 U.S.C. 6295(e)(6)(A)(i), grid-enabled water heaters must possess an activation lock that requires a key to enable the product to operate at its designed specifications and capabilities and without which activation the product will provide not greater than 50 percent of the rated first hour delivery of hot water certified by the manufacturer. This requirement sets these products apart from other large electric storage water heaters with grid connectivity.

iv. Small Electric Storage Water Heaters and Tabletop Water Heaters

Current product classes for electric storage water heaters are based on rated storage volume (capacity) and draw pattern. *See* 10 CFR 430.32(d). There are product classes for electric storage water heaters with storage volumes greater than 20 gallons and less than or equal to 55 gallons, and product classes for electric storage water heaters with storage volumes greater than 55 gallons and less than or equal to 120 gallons. As discussed in section II.B.2 of this document, DOE received a Joint Stakeholder Recommendation for amended water heater standards that included recommended standard levels for electric storage water heaters. In particular, the Joint Stakeholder Recommendation suggested setting different standards for smaller electric storage water heaters. In the July 2023 NOPR, DOE tentatively concluded that separate product classes for smaller electric storage water heaters are warranted. 88 FR 49058, 49080–81. Specifically, DOE noted that market data for electric storage water heaters suggest there is a certain category of electric storage water heaters that are limited in their physical size due to the places they are typically installed, which are commonly referred to as "lowboy" water heaters. The physical size limitation of these water heaters restricts the amount of hot water that can be provided to the household. *Id.*

In reviewing the market for these water heaters, DOE found that most "small electric storage water heaters" offer an effective storage volume greater than or equal to 20 gallons and less than or equal to 35 gallons and deliver FHRs less than 51 gallons. Due to their low capacities, "small electric storage water heaters" fall into the very small or low usage draw patterns. Thus, DOE tentatively concluded that this physical limitation is a performance-related feature affecting energy efficiency that would warrant a separate product class. DOE also explained that the physical size limitation constrains the technology options that can be considered to increase the efficiency of these water heaters. DOE, therefore, analyzed splitting the existing 20–55-gallon product classes for electric storage water heaters by establishing new “small electric storage water heater” product classes. *Id*.

In the July 2023 NOPR, DOE identified the following proposed product classes for electric storage water heaters: (1) electric storage water heaters with an effective storage volume greater than or equal to 20 gallons and less than or equal to 35 gallons, with FHRs less than 51 gallons (i.e., very small and low draw patterns) (“small electric storage water heaters”); and (2) electric storage water heaters with an effective storage volume greater than or equal to 20 gallons and less than or equal to 55 gallons (excluding small electric storage water heaters).

Responding to the July 2023 NOPR, NEEA supported DOE’s proposed creation of the small electric storage water heater product class, and noted that heat pump water heaters are sometimes too large to physically fit in the spaces currently occupied by these types of water heaters. (NEEA, No. 1199 at p. 8) The CA IOUs also supported DOE’s proposal to create a new product class and separate electric resistance-level standards for small electric storage water heaters with effective storage volumes of ≥ 20 and ≤ 35 gallons limited to very small and low draw patterns. The CA IOUs agreed with DOE that there is a specific practicality provided by small electric resistance water heaters (also referred to as “lowboys”), and that it is impractical to install currently available heat pump water heater in some spaces where lowboy water heaters are commonly installed. (CA IOUs, No. 1175 at p. 3)

Rheem asserted that a large portion of 35–40-gallon heat pump water heater sales would be at risk with the structure of the product classes proposed in the July 2023 NOPR. Rheem stated that either the threshold for small electric storage water heaters should be lowered to 30 gallons or the small electric storage water heater category be additionally restricted to products less than 36 inches in height (*i.e.*, lowboys). (Rheem, No. 1177 at p. 7)

PHCC stated that if DOE wished to limit certain products based on effective storage volume, the height is not a significant factor. The commenter asked DOE about the relevance of establishing the small electric storage water heater class based on a 36-inch height limitation while asserting that removing a height consideration would take pressure off the industry and streamline available models. PHCC also suggested DOE adjust the current heat pump-level standard for >55-gal electric storage water heaters to apply to those >40 gallons as well. (PHCC, No. 1151 at p. 2)

DOE is aware that certain 20‒55-gallon heat pump water heaters may be interchangeable for some of the larger electric resistance water heaters in the small electric storage water heater product class and agrees with Rheem that some small electric storage water heaters may be substituted for larger products that would be subject to more stringent standards. As discussed in section IV.G.1 of this document, DOE has accounted for this in its analysis. Although the current limitation could lead to more substitution than if the volume threshold were lowered, DOE believes the small electric storage water heater product class, as proposed in the July 2023 NOPR, strikes the balance between preserving consumer utility at smaller storage volumes and ensuring heat pump water heaters are utilized where practicable to install. As such, DOE is adopting the small electric storage water heater product class, as proposed in the July 2023 NOPR. In response to PHCC, DOE notes that although a height restriction was included in the Joint Stakeholder Recommendation, DOE did not propose a height restriction on the small electric storage water heater product class in the July 2023 NOPR. As shown in Table IV.4 of the July 2023 NOPR, small electric storage water heaters are defined by volume and delivery capacity only. 88 FR 49058,49081. Additionally, DOE notes that PHCC's suggestion for expanding the applicability of heat pump-level standards is essentially what was proposed and is being adopted in this final rule. DOE is using a 35-gallon effective storage volume cutoff combined with a draw pattern requirement for small electric storage water heaters to be in the very small or low draw patterns. In its market assessment, DOE found that many products with nominal volumes of 40 gallons have rated storage volumes from 35 to 36 gallons because manufacturers may nominally report volumes that are within 10 percent of the actual storage volume. With respect to Rheem's suggestion that a height requirement be implemented, DOE notes that although most products on the market that fit into this category are "lowboy" products with limited overhead space, there are also products on the market that are physically constrained by their width or diameter. These tall, small-diameter water heaters also have smaller storage capacities and delivery capacities. They also have the same energy consumption characteristics as lowboy water heaters based on certification data. In the April 2010 Final Rule, when DOE had first declined to establish a separate product class for lowboy water heaters, DOE stated that it does not believe each different combination of physical dimensions currently available on the market warrants a separate product class. 75 FR 20112, 20131-20132. Consistent with the approach taken in the previous rulemaking, DOE has determined that separate standards for lowboy water heaters and these other shapes of small electric storage water heaters are not justified and, as a result, the product class definition should not specify a height restriction.

Tabletop water heaters, which typically have rated storage volumes of around 35 gallons, also have very particular dimensions in order to be used in a kitchen workspace. DOE is not amending the standards for tabletop water heaters in this final rule based on the market assessment for these products (*see* section IV.C.2 of this document for details). There are only two basic models of tabletop water heaters on the market currently. Because of the similarities between tabletop water heaters and small electric storage water heaters, DOE proposed, in the July 2023 NOPR, to create alignment between the standards for these types of products. Specifically, DOE proposed to amend the definition of "tabletop water heater" to specify that the tabletop designation of electric storage water heaters is only applicable to products in the very small or low draw pattern, and any tabletop water heaters in the medium and high draw patterns would henceforth be considered in the broader electric storage water heater product classes. 88 FR 49058, 49081. In the July 2023 NOPR, DOE requested comment on its proposal to limit the tabletop water heater designation to products in the very small and low draw patterns.

In response, AHRI supported the proposal to limit the tabletop water heater designation to the products in the very small and low draw patterns as it will prevent the use of tabletop water heaters as an avenue to bypass the current limitations on small electric storage water heaters. (AHRI, No. 1167 at p. 10) The Joint Advocacy Groups also supported DOE's proposal to limit the tabletop water heater designation to products in the very small and low draw patterns, as it would align the standards for tabletop water heaters with those for small electric storage water heaters and help ensure tabletop water heaters are not used as a less efficient substitute for conventional electric storage water heaters. (Joint Advocacy Groups, No. 1165 at pp. 6–7) Rheem supported DOE's proposed amendments to the tabletop water heater definition, indicating that this otherwise low-sales-volume product has the potential to be installed in place of heat pump water heaters. (Rheem, No. 1177 at p. 8) A.O. Smith supported the changes proposed to the tabletop water heater standards even though it asserted that this may cause some issues for existing products. (A.O. Smith, No. 1182 at p. 15)

BWC stated that re-defining tabletop water heaters as products that only meet either the very small or low draw pattern would remove half of the products from the market, even though this is a very small number of models. As a result, BWC stated, there would be a drastic reduction in model availability for consumers who rely on tabletop water heaters, many of which may be in densely populated, low-income households that have higher household occupancies and therefore require products with delivery capacities in the medium draw pattern. (BWC, No. 1164 at pp. 15–16)

In response to BWC, DOE notes that, in its market assessment of tabletop water heaters, there are only two basic models found to be certified and commercially available. One is in the low draw pattern, and the other has an FHR of 55 gallons, putting it into the medium draw pattern. Water heaters with FHRs less than 51 gallons can remain categorized as tabletop water heaters. Because the medium draw pattern tabletop water heater on the market today is very close to this FHR cutoff, in the July 2023 NOPR, DOE surmised that, with minimal design changes, a modified version of this model may remain on the market and be certified in the tabletop water heater category (*see* 88 FR 49058, 49081). This would avoid limitations to consumer choice. In written comments in response to the NOPR, the two manufacturers that produce tabletop water heaters both supported the proposed updates to the tabletop water heater definition. Additionally, DOE is not aware of, nor did BWC provide, information to support BWC's assertion that many tabletop water heaters are used in households with higher occupancies that require the medium draw pattern. Therefore, DOE is finalizing the definition for tabletop water heaters as proposed.

Additionally, given these insights regarding the market for tabletop water heaters, DOE is amending the product classes for tabletop water heaters to remove the storage volume-based product class boundary at 120 gallons. Comments indicate that the market for these products is limited and requires the specific use of the rectangular casing configuration with typical dimensions of 36 inches high, 25 inches deep, and 24 inches wide. The maximum possible volume contained in these dimensions is approximately 94 gallons, hence DOE does not expect there to exist a market for tabletop water heaters larger than 120 gallons. The amended product class structure for tabletop water heaters results in two volume-based categories: products less than 20 gallons, and products greater than or equal to 20 gallons.

v. Very Large Electric Storage Water Heaters

Responding to the July 2023 NOPR, Bosch, the Joint Advocacy Groups, the CA IOUs, Rheem, A.O. Smith, and AHRI all expressed concern that defining the > 120-gallon electric storage water heater product class in terms of effective storage volume (rather than rated storage volume) could pose backsliding concerns given that it would be possible for electric resistance storage water heaters between 55 and 120 gallons to increase their effective storage volume to over 120 gallons by elevating tank temperatures, such that these products could circumvent the existing heat pump-level standards for electric storage water heaters which apply to rated storage volumes between 55 and 120 gallons. (Bosch, No. 1204 at pp. 2–3; Joint Advocacy Groups, No. 1165 at p. 8; CA IOUs, No. 1175 at pp. 3–4; Rheem, No. 1177 at p. 3; A.O. Smith, No. 1182 at p. 14; AHRI, No. 1167, pp. 5–6) Bosch and the CA IOUs also suggested that defining the greater than 120-gallon electric storage water heater product class in terms of effective storage volume could encourage a market shift towards larger electric resistance storage water heaters in place of smaller, < 55-gallon heat pump water heaters. (Bosch, No. 1204 at pp. 2–3; CA IOUs, No. 1175 at pp. 3–4) Rheem noted that a product with a rated storage volume of 75 gallons could achieve an effective storage volume of 120 gallons at a storage tank temperature of 160 °F. (Rheem, No. 1177 at p. 3)

Multiple stakeholders suggested remedies to this potential problem. Bosch recommended that all electric storage water heaters (apart from very small electric storage water heaters) be required to utilize heat pump technology. (Bosch, No. 1204 at pp. 2–3) The CA IOUs suggested that DOE amend the calculations for effective storage volume such that products with rated storage volumes less than or equal to 120 gallons would be capped at an effective storage volume of 120 gallons. (CA IOUs, No. 1175 at pp. 3–4) Rheem suggested that DOE exempt products with rated storage volumes greater than 120 gallons from the high temperature test method because a > 120-gallon product can already provide the same or more hot water than a heat pump water heater and thus does not rely on increasing its temperature to have a large effective storage volume. (Rheem, No. 1177 at p. 3) NYSERDA suggested that, rather than creating a separate product class for electric storage water heaters > 120 gallons, DOE could instead remove the 120-gallon cap and apply the same standards for electric storage water heaters > 55 gallons to those > 120 gallons. (NYSERDA, No. 1192 at p. 5)

DOE agrees with stakeholders that defining the > 120-gallon electric storage water heater product class in terms of effective storage volume, rather than rated storage volume, would pose a backsliding risk. However, as discussed in V.D.1 of this document, the high-temperature test method does not apply to water heaters that are larger than 55 gallons in rated storage volume. Therefore, the scenarios described above of an electric resistance water heater having a rated volume less than 120 gallons and an effective storage volume greater than 120 gallons is not likely to occur without the use of the high temperature test method. As a result, there would be no risk of backsliding for these standards.

2. Technology Options

DOE conducts a technology assessment to identify a complete list of technologies for consumer water heaters ("technology options") with the potential to improve the UEF ratings of products. Section IV.B of this document describes the process by which technology options are screened in a separate screening analysis that aims to determine which technology options could feasibly be adopted based on five screening criteria. In the engineering analysis (section IV.C of this document), DOE selects the technology options that are most likely to constitute the design pathway to higher efficiency levels in a standards-case scenario (thereafter referred to as “design options”). Thus, after DOE identifies a comprehensive list of technologies for the technology assessment, the subsequent analysis focuses only on those technologies that are the most likely to be implemented in response to amended standards. In the July 2023 NOPR, DOE presented a list of technologies that it identified for initial consideration in the NOPR analysis. 88 FR 49058, 49082–49083.

In the technology assessment for the July 2023 NOPR, DOE examined 120-volt heat pump water heater technology and noted that there were very few models of 120-volt heat pump water heater available on the market at the time. DOE therefore requested comment on the outlook for the emergence of 120-volt heat pump water heaters, information regarding how their design and operation could differ from 240-volt heat pump water heaters, and data on performance characteristics and efficiencies. 88 FR 49058, 49082.

In response, AWHI commented that NEEA’s Advanced Water Heating Specification version 8.01 contains a technical specification for a load shifting-capable 120-volt heat pump water heater, and that there are now three manufacturers that offer commercially available 120-volt heat pump water heaters ranging from 50 to 80 gallons. AWHI cited a preliminary market assessment conducted by New Buildings Institute stating that 22 to 30 percent of existing California homes could transition from fossil fuel-based water heaters to 120-volt heat pump water heaters without substantial site upgrades, and that the installation cost of 120-volt heat pump water heaters is significantly less that for 240-volt units due to minimal electrical interventions. AWHI stated that 120-volt heat pump water heaters do not need a dedicated circuit to be installed and can instead share a circuit with other appliances, reducing the impact of installation on the existing electrical infrastructure of the home. AWHI also stated that 120-volt heat pump water heaters do not have electric resistance elements, which results in slower recovery than 240-volt heat pump water heaters and are therefore more sensitive to environmental factors that impact compressor performance, such as input water temperature and ambient air temperature. AWHI stated that 120-volt heat pump water heaters incorporate integrated mixing valves and store water at temperatures above the delivery temperature to increase hot water capacity, which allows for easier participation in load shifting and demand-response programs. Lastly, AWHI stated that a 120-volt heat pump water heater performed at an overall average UEF of 2.90 and varied by season and use characteristics in a field study conducted in California by New Buildings Institute. (AWHI, No. 1036 at pp. 1–3)

BWC supported DOE's tentative determination not to include 120-volt heat pump water heaters in its analysis because these products are relatively new and do not have significant market share at the present time. BWC stated a belief that it is appropriate for DOE, and the industry, to take more time to better understand these products before establishing regulations. (BWC, No. 1164 at p. 14)

DOE appreciates the insight into 120-volt heat pump water heaters and continues to evaluate this technology. While DOE considers 120-volt heat pump water heaters to be a technology for improving the efficiency of electric water heaters, due to the nascent status of 120-volt heat pump water heaters, DOE did not consider 120-volt designs to constitute the main pathway towards higher efficiency for electric storage water heaters. However, as discussed in section V.C.1 of this document, the Department assessed TSLs with consideration of these designs. Specifically, when evaluating TSLs, DOE considered whether the potential standards levels would likely prevent new 120-volt designs from emerging onto the market.

Responding to the July 2023 NOPR, NEEA supported DOE's inclusion of the gas pressure-actuated non-powered damper as a technology option, stating that it is likely the lowest cost pathway to achieving EL 2. (NEEA, No. 1199 at p. 9) DOE has maintained non-powered dampers as a technology option for the final rule.

Additionally, while DOE identified modulating burners as a technology option for all gas-fired water heaters in the July 2023 NOPR technology analysis, DOE tentatively determined that modulating burners were used to increase UEF only in instantaneous gas-fired water heaters. 88 FR 49058, 49082. DOE did not receive any comments on that tentative determination. As discussed in section II.B.3 of this document, gas-fired instantaneous water heaters are no longer within the scope of this rulemaking. However, modulating burners could still be used in circulating gas-fired water heaters, which are a type of gas-fired storage water heater. Hence, in light of the classification of circulating water heaters as storage-type water heaters (*see* section IV.A.1.a of this document), DOE is retaining modulating burners in its list of technology options investigated for this final rule; however, as shown in chapter 5 of the TSD, modulating burners are not expected to be part of the representative, cost-effective design pathway to increasing efficiency for gas-fired storage water heaters. The technology options for Improving UEF in consumer water heaters are listed in Table IV.5Table IV.5Table IV.5 and described in chapter 3 of the final rule TSD.

Table IV.5 Potential Technologies for Increasing Consumer Water Heater Efficiency

Technology Option		
Heat traps		
Improved insulation	Increased thickness	
	Insulation on tank bottom	
	Less conductive tank materials (*e.g.*, plastic)	
	Foam insulation	
	Pipe and fitting insulation	
	Advanced insulation types	Aerogel
		Vacuum panels
		Inert gas-filled panels
Electronic ignition systems	Direct spark ignition	
	Intermittent pilot ignition	
	Hot surface ignition	
Improved burners	Pulse combustion	
	Pressurized combustion	
	Side-arm heating	
	Two-phase thermosiphon technology	
	Modulating burners	Step Modulating Burners
		Fully Modulating Burners
	Reduced burner size (slow recovery)	
Heat exchanger improvements	Increased heat exchanger surface area	
	Enhanced flue baffle	
	Submerged combustion chamber	
	Multiple flues	
	Alternative flue geometry (Helical)	
	U-Tube	
	Condensing technology	
	Induced-draft (negative vent pressure) heat exchanger	
	Direct-fired heat exchange	
Improved venting	Flue damper	Externally-powered
		Thermopile-operated (non-powered)
		Gas-actuated (non-powered)
		Buoyancy-operated (non-powered)
	Concentric direct venting	
	Power vent	
Improved heat pump water heater components	Compressor improvements	Increased capacity
		Increased efficiency

Technology Option		
		Variable-speed drive
	Fan improvements	High-efficiency fan motors
		High-efficiency fan blades
	Expansion device improvements	
	Increased evaporator surface area	
	Increased condenser surface area	
Gas-fired absorption heat pump water heaters		
Gas-fired adsorption heat pump water heaters		
Carbon dioxide heat pump water heaters		
Thermophotovoltaic and thermoelectric generators		
Improved controls	Modulating controls	

B. Screening Analysis

DOE uses the following five screening criteria to determine which technology options are suitable for further consideration in an energy conservation standards rulemaking:

1) Technological feasibility. Technologies that are not incorporated in commercial products or in commercially viable, existing prototypes will not be considered further.

2) Practicability to manufacture, install, and service. If it is determined that mass production of a technology in commercial products and reliable installation and servicing of the technology could not be achieved on the scale necessary to serve the relevant market at the time of the projected compliance date of the standard, then that technology will not be considered further.

3) Impacts on product utility. If a technology is determined to have a significant adverse impact on the utility of the product to subgroups of consumers, or result in the unavailability of any covered product type with performance characteristics (including reliability), features, sizes, capacities, and volumes that are substantially the same as products generally available in the United States at the time, it will not be considered further.

4) Safety of technologies. If it is determined that a technology would have significant adverse impacts on health or safety, it will not be considered further.

5) Unique-pathway proprietary technologies. If a technology has proprietary protection and represents a unique pathway to achieving a given efficiency level, it will not be considered further, due to the potential for monopolistic concerns.

10 CFR part 430, subpart C, appendix A, sections 6(b)(3) and 7(b).

In sum, if DOE determines that a technology, or a combination of technologies, fails to meet one or more of the listed five criteria, it will be excluded from further consideration in the engineering analysis. The reasons for eliminating any technology are discussed in the following sections.

The subsequent sections include comments from interested parties pertinent to the screening criteria, DOE's evaluation of each technology option against the screening analysis criteria, and whether DOE determined that a technology option should be excluded ("screened out") based on the screening criteria.

1. Screened-Out Technologies

The following subsections describe the technologies that DOE eliminated for failure to meet one of the following five factors: (1) technological feasibility; (2) practicability to manufacture, install, and service; (3) impacts on equipment utility or equipment availability; (4) adverse impacts on health or safety; and (5) unique-pathway proprietary technologies.

In the July 2023 NOPR, DOE screened out the following technology options based on the above criteria: absorption and adsorption heat pump water heaters, advanced insulation types, condensing pulse combustion, direct-fired heat exchange, dual-fuel heat pumps, buoyancy-operated flue dampers, thermopile-operated flue dampers, reduced burner size (slow recovery), side-arm heating, two-phase thermosiphon technology, and U-tube flues. 88 FR 49058, 49083. Each of these technology options and the reasons for which they were screened out are discussed in detail in chapter 4 of the final rule TSD.

BWC stated that it is aware of exclusive intellectual property protections that it asserted may inhibit manufacturers from utilizing certain technologies that are assumed by DOE to be available in the market to increase energy efficiency on certain consumer water heater products, and that BWC would be able to provide information in a confidential interview with DOE's consultants. (BWC, No. 1164 at p. 16)

In selecting design options to improve efficiency in the engineering analysis, DOE performed teardowns of models manufactured by multiple companies to ensure that each efficiency level is achievable using non-proprietary designs.

BWC supported DOE's tentative determination not to consider thermopile-powered flue dampers for gas-fired storage water heaters. (BWC, No. 1164 at p. 16)

BWC stated that direct-vent and power-direct-vent gas-fired water heaters are not necessarily unsafe, but that their construction imposes limits on how these products can vent and operate; a major consideration for these products would be restrictions on the maximum allowable vent length that safety standards would permit. BWC requested that DOE consider these venting factors for gas-fired water heaters to avoid unintentionally encouraging installations that conflict with the requirements of safety standards such as ANSI Z21.10.1 and ANSI Z21.10.3. (BWC, No. 1164 at p. 16)

DOE agrees with BWC that direct-vent and power-direct-vent gas-fired water heaters are safe to use when installed and operated in accordance with manufacturer recommendations and/or applicable safety standards. Therefore, DOE has not screened these technologies out of its analysis. In evaluating these technologies, DOE accounts for the necessary differences in venting systems installations (*see* section 0 of this document).

2. Remaining Technologies

Through a review of each technology, DOE concludes that all of the other identified technologies listed in section 0 of this document meet all five screening criteria to be examined further as design options in DOE’s final rule analysis. In summary, DOE did not screen out the following technology options listed in Table IV.6. These technology options are shown from left to right from broader categories to specific design options.

Table IV.6 Remaining Technology Options

<table>
<tr><th colspan="4">Technology Option</th></tr>
<tr><td colspan="2" rowspan="5">Improved insulation</td><td colspan="2">Increased thickness</td></tr>
<tr><td colspan="2">Insulation on tank bottom</td></tr>
<tr><td colspan="2">Less conductive tank materials (e.g., plastic)</td></tr>
<tr><td colspan="2">Foam insulation</td></tr>
<tr><td colspan="2">Pipe and fitting insulation</td></tr>
<tr><td colspan="2" rowspan="3">Electronic ignition systems</td><td colspan="2">Direct spark ignition</td></tr>
<tr><td colspan="2">Intermittent pilot ignition</td></tr>
<tr><td colspan="2">Hot surface ignition</td></tr>
<tr><td colspan="2" rowspan="3">Burner improvements</td><td colspan="2">Pressurized combustion</td></tr>
<tr><td rowspan="2">Modulating burners</td><td>Step modulating burners</td></tr>
<tr><td>Fully modulating burners</td></tr>
<tr><td colspan="2" rowspan="7">Gas-fired and Oil-fired Heat exchanger improvements</td><td colspan="2">Increased heat exchanger surface area</td></tr>
<tr><td colspan="2">Enhanced flue baffle</td></tr>
<tr><td colspan="2">Submerged combustion chamber</td></tr>
<tr><td colspan="2">Multiple flues</td></tr>
<tr><td colspan="2">Alternative flue geometry (Helical)</td></tr>
<tr><td colspan="2">Condensing technology</td></tr>
<tr><td colspan="2">Induced-draft (negative vent pressure) heat exchanger</td></tr>
<tr><td colspan="2" rowspan="4">Improved venting</td><td rowspan="2">Flue damper</td><td>Externally-powered</td></tr>
<tr><td>Gas-actuated (non-powered)</td></tr>
<tr><td colspan="2">Power vent</td></tr>
<tr><td colspan="2">Concentric direct venting</td></tr>
<tr><td rowspan="9">Improved heat pump water heater components</td><td rowspan="3">Compressor improvements</td><td colspan="2">Increased capacity</td></tr>
<tr><td colspan="2">Increased efficiency</td></tr>
<tr><td colspan="2">Variable-speed drive</td></tr>
<tr><td rowspan="2">Fan Improvements</td><td colspan="2">High-efficiency fan motors</td></tr>
<tr><td colspan="2">High-efficiency fan blades</td></tr>
<tr><td colspan="3">Expansion device improvements</td></tr>
<tr><td colspan="3">Increased evaporator surface area</td></tr>
<tr><td colspan="3">Increased condenser surface area</td></tr>
<tr><td colspan="3">Carbon dioxide (alternative refrigerant) heat pump water heaters</td></tr>
<tr><td colspan="2">Improved controls</td><td colspan="2">Modulating controls</td></tr>
<tr><td colspan="4">Heat traps (all types)</td></tr>
</table>

DOE determined that these technology options are technologically feasible because they are being used or have previously been used in commercially available products or working prototypes. DOE also finds that all of the remaining technology options meet the other screening criteria (*i.e.*, practicable to manufacture, install, and service and do not result in adverse impacts on consumer utility, product availability, health, or safety). For additional details, *see* chapter 4 of the final rule TSD.

C. Engineering Analysis

The purpose of the engineering analysis is to establish the relationship between the efficiency and cost of consumer water heaters. There are two elements to consider in the engineering analysis; the selection of efficiency levels to analyze (*i.e.*, the "efficiency analysis") and the determination of product cost at each efficiency level (*i.e.*, the "cost analysis"). In determining the performance of higher-efficiency products, DOE considers technologies and design option combinations not eliminated by the screening analysis. For each product class, DOE estimates the baseline cost, as well as the incremental cost for the product at efficiency levels above the baseline. The output of the engineering analysis is a set of cost-efficiency "curves" that are used in downstream analyses (*i.e.*, the LCC and PBP analyses, the MIA, and the NIA).

As discussed in section IV.A.1 of this document, certain classes of consumer water heaters currently have UEF-based standards, while for others EPCA's EF-based standards apply. For this rulemaking, DOE analyzed amended UEF standards for the product classes that currently have standards in terms of UEF. For the product classes with EF-based standards, DOE developed translated standards in terms of UEF for use in the analysis.

In this final rule, DOE has analyzed standards with respect to the effective storage volume metric (as proposed in the July 2023 NOPR). Compared to rated storage volume and FHR, effective storage volume is a superior descriptor of the thermal energy stored in the hot water of the water heater which can be made immediately available for consumer use. As outlined in the July 2023 NOPR, there are two types of water heaters that can cause the system to store more energy than would be otherwise determined by the rated storage volume: (1) water heaters capable of operating with an elevated tank temperature, and (2) circulating water heaters. 88 FR 49058, 49086. In the June 2023 TP Final Rule, DOE established that compliance with the effective storage volume provisions (and, relatedly, the high temperature testing method and testing with separate storage tanks for circulating water heaters) would not be required until compliance with amended standards is required. For circulating water heaters, the effective storage volume of the water heater is determined by the measured storage volume of the separate storage tank used in testing because these types of water heaters are designed to operate with a volume of stored water in the field. 88 FR 40406, 40461–40462. Certain provisions for circulating water heater testing are discussed further in detail in section V.D.2 of this document. Section V.D.1 of this document discusses the proposed approach to consider efficiency determinations for water heaters tested using the high temperature testing method.

In the July 2023 NOPR, DOE tentatively determined not to propose amended standards for gas-fired storage water heaters (55 gal $< V_{eff} \leq$ 100 gal), tabletop water heaters (20 gal ≤ V_{eff} ≤ 120 gal), electric instantaneous water heaters (V_{eff} < 2 gal), and grid-enabled water heaters at that time based on the results of the market and technology assessment, screening analysis, interviews with manufacturers, and comments from interested parties. These assessments were discussed further in chapters 3 and 5 of the NOPR TSD. 88 FR 49058, 49086.

In this final rule, DOE has maintained the analytical approaches proposed in the July 2023 NOPR. For circulating water heaters, as discussed in section IV.A.1.a of this document, based on information from the December 2023 SNOPR, DOE has determined that these products offer the same consumer utility as storage-type water heaters, so the storage-type water heater standards would apply. In summary, Table IV.7 presents the consumer water heater product classes along with the approach to analyzing them for this final rule.

Table IV.7 Analysis Approach by Product Class

Product Category Analyzed in this Final Rule	Distinguishing Characteristics (Effective Storage Volume and Input Rating)	Analysis
Gas-fired Storage Water Heater	< 20 gal	Converting EF-based standards to UEF-based standards
	≥ 20 gal and ≤ 55 gal	Amending UEF-based standards
	> 55 gal and ≤ 100 gal	No amendments
	> 100 gal	Converting EF-based standards to UEF-based standards
Oil-fired Storage Water Heater	≤ 50 gal	Amending UEF-based standards
	> 50 gal	Converting EF-based standards to UEF-based standards
Electric Storage Water Heater	< 20 gal	Converting EF-based standards to UEF-based standards
	≥ 20 gal and ≤ 35 gal, FHR < 51 gal (Small electric storage water heaters)	Amending UEF-based standards
	≥ 20 gal and ≤ 55 gal, excluding small electric storage water heaters	Amending UEF-based standards
	> 55 gal and ≤ 120 gal	Amending UEF-based standards
	> 120 gal	Converting EF-based standards to UEF-based standards
Tabletop Water Heater	< 20 gal	Converting EF-based standards to UEF-based standards
	≥ 20 gal and ≤ 120 gal	Remove boundary at 120 gal due to these sizes not being feasible within the description of a tabletop water heater
Electric Instantaneous Water Heater (including Low-Temperature Water Heaters)	< 2 gal	No amendments
	≥ 2 gal	Converting EF-based standards to UEF-based standards
Grid-enabled Water Heater	> 75 gal	No amendments
Circulating Water Heater	All Sizes	Included as storage-type water heaters

Several commenters provided feedback about transitioning the energy conservation standards from a rated storage volume basis to an effective storage volume basis.

AHRI provided comments emphasizing the possibility of market confusion resulting from amended standards being prescribed in terms of effective storage volume instead of rated storage volume, noting that the previous conversion from the EF to the UEF metric itself was not without issue, leading to market disruption given that utility programs across the United States and in Canada have still not fully adopted the UEF metric. AHRI stated that the effective storage volume metric needs to be further scrutinized to evaluate the representativeness and repeatability of the metric, and that manufacturers require additional time to analyze the effective storage volume calculation to determine its accuracy, representativeness, and repeatability, as well as to conduct laboratory testing to this end. AHRI asserted that the 60-day comment period for the July 2023 NOPR was insufficient to conduct this review. AHRI recommended using only effective storage volume in the energy conservation standards equations for products for which the metric applies to limit confusion. (AHRI, No. 1167 at p. 5) AHRI requested clarification on whether the effective storage volume metric would apply to grid-enabled water heaters, tabletop water heaters, and electric instantaneous water heaters larger than 2 gallons in rated storage volume, recommending that the effective storage volume metric not apply to grid-enabled water heaters. AHRI proposed two possible options to mitigate potential market confusion from the new effective storage volume metric: use rated storage volume for all product categories not subject to high temperature testing; or (the option AHRI stated was less preferable), include a footnote with the standards to indicate those product categories for which effective storage volume is identical to rated storage volume. (AHRI, No. 1167 at p. 6)

BWC commented that the replacement of the rated storage volume metric with effective storage volume deviates from the Joint Stakeholder Recommendation and could create situations where products may not be capable of supplying adequate hot water to the home. (BWC, No. 1164 at p. 1) BWC requested DOE not change the standards for all product classes to be in terms of effective storage volume, but instead to use the new metric only for product classes for which the rated storage volume and effective storage volume are expected to be different in order to avoid confusion. (BWC, No. 1164 at p. 9)

CEC identified a drafting error in the proposed regulatory language in the heading at 10 CFR 430.32(d)(1) and (2), where “rated storage volume” is used rather than “effective storage volume.” (CEC, No. 1173 at pp. 12–13) This was a publication error printed at 88 FR 49058, 49176. Stakeholders were notified of this typographical error in the September 13 Public Meeting. (Public Meeting Transcript, No. 1190 at p. 101).

In response, DOE maintains that effective storage volume is appropriate for use for all classes. In light of the reclassification of circulating water heaters as storage-type water heaters, defining all classes in terms of effective storage volume (rather than just electric storage classes, as was suggested by stakeholders) and delineating the standards as a function of effective storage volume is necessary to ensure the appropriate classification of these products. More specifically, because circulating water heaters will be considered part of the storage-type product classes, the same standards will apply to circulating water heaters. Where the standards for storage-type product classes are linear functions of volume, the purpose of this is to account for the additional standby loss that comes with more hot water being contained in the system. The effective storage volume of a circulating water heater is what captures the amount of hot water contained in this type of system, and therefore is most appropriate to base the standards equations on. Stakeholders correctly noted that the use of the high temperature test method (described in section V.D.1), which will apply to certain types of electric storage water heaters, is one way by which a model can have an effective storage volume different from its rated storage volume. Further, per section 6.3.1.1 of appendix E test procedure, the effective storage volume can be higher than the rated storage volume for any storage-type water heater if the mean tank temperature is more than 5 °F higher than the delivery temperature (*see* section V.D.1 of this document for details). Therefore, DOE adopts use of effective storage volume rather than storage volume in this final rule.

1. Product Classes with Current UEF-based Standards

DOE typically uses one of two approaches to develop energy efficiency levels for the engineering analysis: (1) relying on observed efficiency levels in the market (*i.e.*, the efficiency-level approach), or (2) determining the incremental efficiency improvements associated with incorporating specific design options to a baseline model (*i.e.*, the design-option approach). Using the efficiency-level approach, the efficiency levels established for the analysis are determined based on the market distribution of existing products (in other words, based on the range of efficiencies and efficiency-level "clusters" that already exist on the market). Using the design option approach, the efficiency levels established for the analysis are determined through detailed engineering calculations and/or computer simulations of the efficiency improvements from implementing specific design options that have been identified in the technology assessment. DOE may also rely on a combination of these two approaches. For example, the efficiency-level approach (based on actual products on the market) may be extended using the design-option approach to "gap fill" levels (to bridge large gaps between other identified efficiency levels) and/or to extrapolate to the max-tech level (particularly in cases where the max-tech level exceeds the maximum efficiency level currently available on the market).

In the July 2023 NOPR, DOE developed efficiency levels with a combination of the efficiency-level and design-option approaches. DOE conducted a market analysis of currently available models listed in DOE's CCD to determine which efficiency levels were most representative of the current distribution of consumer water heaters available on the market. DOE also completed physical teardowns of commercially available units to determine which design options manufacturers may use to achieve certain efficiency levels for each water heater category analyzed. DOE requested comments from stakeholders and conducted interviews with manufacturers concerning these initial efficiency levels, which have been updated based on the feedback DOE received.

a. Efficiency Levels

In this final rule, as noted previously, DOE has analyzed efficiency levels for UEF that are a function of effective storage volume (with the exception of certain levels which were analyzed when DOE incorporated feedback from the Joint Stakeholder Recommendation). For products with substantial storage volumes, the UEF is expected to decrease with higher volumes because standby losses (*i.e.*, energy lost from the stored water to the surroundings when the water heater is not actively heating water) are related to the temperature of the water stored and the size of the tank.[36] The efficiency levels analyzed in this rulemaking assume that the relationships between standby losses and storage volume for baseline products (*i.e.*, the slopes of the current standards equations) would remain consistent for higher efficiency levels. In other words, the higher efficiency levels are linear equations that are parallel to the current standards. The exception to this is for DOE's analysis of the Joint Stakeholder Recommendation, which included certain efficiency levels that were not specified as a function of storage volume.

In this final rule, DOE has analyzed the same efficiency levels as were considered in the July 2023 NOPR. The details of the efficiency level analysis are presented in chapter 5 of the final rule TSD, and a summary of the efficiency levels is presented in the following sections.

i. Baseline Efficiency

For each product class, DOE generally selects a baseline model as a reference point for each class and measures changes resulting from potential energy conservation standards against the baseline. The baseline model in each product class represents the characteristics of a product/equipment typical of that class (*e.g.*, capacity, physical size). Generally, a baseline model is one that just meets current energy conservation standards, or, if no standards are in place, the baseline is typically the most common or least efficient unit on the market. For this final rule, the baseline efficiency levels for product

[36] As discussed in section III.C of this document, the effective storage volume metric accounts for both temperature and tank size, whereas rated storage volume alone only accounts for tank size.

classes with current UEF-based standards are equal to the current energy conservation standards (*see* Table II.1).

ii. Higher Efficiency Levels

As part of DOE's analysis, the maximum available efficiency level is the highest efficiency unit currently available on the market. DOE also defines a "max-tech" efficiency level to represent the maximum possible efficiency for a given product.

In July 2023 NOPR, the max-tech efficiency levels generally corresponded to the maximum available efficiency level on the market. DOE also analyzed multiple intermediate efficiency levels between the baseline and max-tech in order to develop the cost-efficiency relationship for each product class. Intermediate efficiency levels were chosen based on the market assessment where there were clear groupings in the market's efficiency distribution. In some cases, efficiency levels were observed for one draw pattern but not the others.

DOE has constructed cost versus efficiency curves for the representative capacities and representative draw patterns which exist on the market today, as opposed to directly analyzing every possible draw pattern. However, DOE is increasing the stringency of standards for draw patterns where products do not currently exist in order to match the stringency of standards for draw patterns where products in the same category do exist, in the event that products become available with draw patterns not currently on the market.

For these cases, DOE estimated these max-tech levels using existing relationships between efficiency levels observed in other draw patterns where products do exist. Products in different draw patterns are typically differentiated by rated storage volume and heating capacity (burner input rate, compressor capacity, or element wattage), and the design options used to improve UEF in one draw pattern can generally also be applied to water heaters of the same type in a different draw pattern. For the cases where products at additional intermediate efficiency levels were observed in the market at one draw pattern but not the others, DOE estimated efficiency levels in the other draw patterns based on what was observed for the one available draw pattern. The approach took into account how each product type's efficiency correlates to its delivery capacity (*i.e.*, either FHR or maximum GPM, the delivery capacity metrics assigned for non-flow-activated water heaters and flow-activated water heaters, respectively), recovery efficiency, and technological feasibility of design-option implementation. A detailed discussion of efficiency level selection on a product-class by product-class basis is provided in chapter 5 of the final rule TSD.

In the NOPR engineering analysis, DOE considered split-system heat pump water heaters as a representative design strategy for small electric storage water heaters because small electric storage water heaters are typically configured for applications with limited vertical clearance. Whereas integrated heat pump water heaters are typically designed with the heat pump components affixed to the top of the storage tank (significantly increasing the height of the water heater), split-system heat pump water heaters have the advantage of being able to install the heat pump in a remote location so that the storage tank height does not change. However, there are currently no models of split-system heat pumps for small electric storage water heaters on the market today, so DOE estimated the performance of a hypothetical design based on circulating heat pump water heaters and lowboy water heaters that were available at the time of the July 2023 NOPR. *See* chapter 5 of the NOPR TSD for further details. To ensure that the analysis is representative, in the July 2023 NOPR, DOE requested information about the potential design specifications, manufacturing processes, and efficiencies of split-system heat pump water heaters. 88 FR 49058, 49091.

In response to DOE's request for information regarding split-system heat pump water heaters, Rheem noted that it had identified a dual-fuel combination heat pump water heater and boiler product manufactured by its sister company in the Netherlands. (Rheem, No. 1177 at p. 8)

DOE reviewed product literature for the dual-fuel split-system heat pump water heater mentioned by Rheem, marketed in the Netherlands as the Intergas Xtend model. While dual-fuel heating is being screened out from this rulemaking analysis (*see* section IV.B.1 of this document), details about this design provide valuable information about the performance potentials for split-system heat pump water heaters (operating in heat pump-only mode). The Xtend split-system heat pump water heater has a reported coefficient of performance ("COP") of 4.68, uses R-32 refrigerant, has a total heating capacity of 5 kW (over 17,000 Btu/h), and is designed for combination space and domestic hot water heating.[37] Based on the COP rating, DOE understands that this product identified by Rheem would likely have a UEF rating higher than the max-tech

[37] Product information can be found online at: *www.intergas-verwarming.nl/consument/producten/xtend/* (Last accessed: Nov. 17, 2023).

efficiency analyzed for small electric storage water heaters. However, after reviewing this design, DOE determined two main factors which lead to uncertainty as to whether this design is viable for small electric storage water heaters. First, the use of R-32 refrigerant (which has not been demonstrated in water heaters in the United States market) and the resulting total capacity of over 17,000 Btu/h is more akin to the designs of single-split space-constrained air-source heat pump air conditioners, which range between 15,200 and 23,800 Btu/h in DOE's CCD. In contrast, teardown analyses of heat pump water heaters show that these systems typically have much smaller compressors than do central (*i.e.*, whole-home) air conditioners, and therefore the Xtend water heater model as well. In addition, due to the higher capacity of the Xtend model, this product is more likely to function in the medium or high draw patterns, meaning that it does not serve the same consumer utility as a small electric storage water heater. This is because a much larger compressor would have very low run time (causing technical difficulties for refrigerant circulation), be noisier, and significantly increase the footprint of the heat pump module. As a result, it remains unclear whether split-system heat pump small electric storage water heaters are able to employ the same design options to achieve the higher efficiency of the Xtend model. DOE will continue to evaluate technologies for split-system heat pump water heaters in future rulemakings addressing consumer water heater standards.

In the July 2023 NOPR, DOE presented its efficiency levels for analysis and specifically requested further information on the technologies employed in 45-gallon medium draw pattern electric storage products at a UEF of 3.50 (which would potentially help with re-evaluating EL 2). 88 FR 49058, 49090. DOE did not, however, receive any comments on this particular topic.

Commenting more specifically on the electric storage water heater efficiency levels analyzed in the July 2023 NOPR, BWC noted that the Joint Stakeholder Recommendation originally suggested a minimum UEF of 2.0 for some of the smallest volumes of electric storage water heaters, and the NOPR proposes a level of 2.3 UEF. BWC asserted that a minimum UEF of 2.0 would be necessary in some products to allow manufacturers more flexibility to innovate new designs and reduce the cost of heat pump water heaters, which it stated will be critical for consumers to purchase these products because key rebates and tax incentives will expire in the early 2030s. However, BWC stated that it still supported electric resistance-level standards for small and very small electric storage water heaters, and that, generally, redesigns for these products would not be necessary to meet the proposed minimum efficiency standards. (BWC, No. 1164 at pp. 1–2)

In response to BWC, DOE notes that products exceeding 2.3 UEF are widely available across a range of capacities, indicating that this level is readily achievable, and thus analyzing an additional efficiency level at a UEF of 2.0 would be unlikely to provide additional benefit. As discussed in chapter 5 of the final rule TSD, a UEF of 2.0 is expected to correspond to split-system heat pump water heaters in the small electric storage water heater product category, which, as a result of the heat pump design, have certain limitations to achieving higher efficiencies. Electric storage water heaters that are not “small electric storage water heaters” do not have the same design limitations and can achieve higher efficiencies with integrated heat pump water heater designs (where the heat pump is adjoined at the top of the tank). Additionally, split-system designs are typically more expensive to manufacture compared to integrated designs, meaning that the most cost-effective pathway to achieving higher efficiencies would most likely be through integrated designs. (*See* section IV.C.1.e of this document and chapter 5 of the final rule TSD for estimated manufacturer production costs of both styles of heat pump designs.) In the selection of efficiency levels for these larger water heaters, DOE considered the certified UEF ratings of integrated heat pump water heaters on the market, the ENERGY STAR v5.0 specification, the Joint Stakeholder Recommendation, and its own test data. Based on these sources, a UEF of 2.3 was determined to be most representative of a low-cost heat pump water heater design for non-small electric storage water heaters.

Earlier in this rulemaking DOE received comments from some stakeholders who suggested that DOE consider establishing a "heat pump-only" level, which would exclude the use of electric resistance elements, as max tech for heat pump water heaters. In the July 2023 NOPR, DOE noted that its own test data indicate that heat pump water heaters with backup electric resistance elements typically do not use the elements during DOE's 24-hour simulated use test. Therefore, adding an efficiency level that corresponds to a "heat-pump only" design option as max tech would not be expected to change the UEF. 88 FR 49058, 49090.

BWC agreed with not including an efficiency level for electric storage water heaters that specifically pertained to a heat pump design that did not have backup electric resistance elements on the basis that not only would a higher efficiency standard pose significant challenges for the industry transition to heat pump water heaters, but also that the efficiency benefits of not having a backup electric resistance element would not be demonstrated by the current appendix E test procedure and UEF metric. (BWC, No. 1164 at pp. 16–17)

Essency stated it has achieved an FHR of 80 gallons and a UEF of 0.93 with electric resistance technology and suggested that max tech for electric resistance water heaters has not yet been reached. (Essency, No. 1194 at p. 1) GreenTECH stated that it is currently developing a fully electric consumer heat pump water heater with projected energy savings of 50 percent compared to current models and that utilizes peak amperage of less than 10 amps at 220 volts for a 50-gallon comparable model. (GreenTECH, No. 71 at p.1)

In response to Essency, DOE previously considered an efficiency level that corresponded to increased insulation for electric resistance storage water heaters (see the March 2022 Preliminary Analysis). However, DOE received many comments from manufacturers indicating that it may not be practical to incorporate more insulation in the manufacturing process, after which DOE had revised EL 1 to reflect a baseline heat pump efficiency instead. 88 FR 49058, 49089. In response to GreenTECH, based on its review of the components that are used in conventional 240-volt heat pump water heaters, DOE expects that there would not be any appreciable difference in technology or design between conventional 240-volt heat pump water heaters and a 220-volt heat pump water heater as described by GreenTECH. However, because GreenTECH did not provide further details regarding their design, which is currently commercially unavailable, DOE was unable to evaluate GreenTECH's suggestions as a max-tech efficiency level.

NEEA urged DOE to consider gas absorption or adsorption heat pump water heaters as max-tech, adding that statutorily, DOE is not limited to commercially available technologies. NEEA noted that multiple technology developers and manufacturers are advancing gas heat pump water heaters for the residential market, many of which are expected to be commercialized by 2025. (NEEA, No. 1199 at pp. 9–10)

In response to comments from NEEA, DOE did not consider gas-fired absorption or adsorption heat pumps for the max-tech levels because, as discussed in section IV.B of this document, these technologies were screened out for not being practicable to manufacture, install, or service on the scale necessary to serve the consumer water heater market upon the compliance date of the amended standards. For more details on the screening analysis, *see* chapter 4 of the final rule TSD.

AWHI encouraged DOE to consider efficiency levels for gas-fired storage water heaters that couple 120-volt electric-readiness with gas-fired water heater installations to minimize the burden of future electrification requirements. AWHI cited a comment from Rheem made in response to the March 2022 Preliminary Analysis recommending that DOE add a higher efficiency level for gas-fired storage water heaters that would require electricity but is achievable with a Category-I venting solution. AHWI stated that adopting such a standard level would, upon the second replacement of an existing gas-fired water heater after the compliance date of this rule, give consumers the option to install drop-in replacement 120-volt heat pump water heaters because the 120-volt electricity connection would already exist (being necessary to meet such a standard). (AWHI, No. 1036 at p. 4)

In response to AWHI, DOE notes that it does consider an efficiency level for gas-fired storage water heaters that requires electricity and is achievable with category I venting, which is identified as EL 2B (see section 0 of this document) and includes an electric flue damper but uses category I venting. Beyond that level, based on review of the market and technologies currently being used, DOE has concluded the most likely design pathway to improved UEF would be to increase flue baffling, which would require use of category III venting (*i.e.*, "power venting").

CEC requested DOE establish more stringent standards for gas-fired storage water heaters and, if necessary, proceed with a separate rule for gas-fired storage water heaters to avoid delaying the finalization of other settled portions of the proposed rule. CEC added that primary innovation needed make substantial efficiency improvements to gas-fired storage water heaters is to implement a spiral flue, which will exchange more heat from the combusted gas to the water. (CEC, No. 1173 at p. 4)

In response to CEC, DOE agrees that a "spiral" (helical) flue is one of the main technological improvements that allows gas-fired storage water heaters to have condensing-level efficiencies. DOE notes that the manufacture and design of these flues is a complicated and expensive process, and spiraling flues have added material costs due to the significantly longer flue length. Additionally, manufacturers must adjust designs to account for the tank volume that the flue takes up: the more space the flue takes up in the tank, the less tank volume there is left to store the hot water. These costs are reflected in the manufacturer production costs ("MPCs") and conversion cost estimates for ELs 4 and 5 for gas-fired storage water heaters, and they eventually result in higher-priced products for consumers. DOE evaluated whether standards at condensing efficiency levels were economically justified taking into account these costs (*see* section V.C.1 of this document.)

After considering these comments, DOE has maintained the efficiency levels from the July 2023 NOPR.

iii. Efficiency Levels by Product Class

DOE's analysis for efficiency levels above baseline is discussed in more detail in chapter 5 of the final rule TSD. Efficiency levels, including baseline and higher efficiencies, across all product classes are listed in the tables that follow. The efficiency levels which correspond closely to the Joint Stakeholder Recommendation are indicated with "JSR".

Table IV.8 Gas-fired Storage: 20 gal ≤ V_{eff} ≤ 55 gal, Standard, Low, and Ultra Low NO_X

Efficiency Level	UEF			
	Very Small*	**Low**	**Medium**	**High**
0 (Baseline)	0.3456 – (0.0020 × V_{eff})	0.5982 – (0.0019 × V_{eff})	0.6483 – (0.0017 × V_{eff})	0.6920 – (0.0013 × V_{eff})
1	0.3725 – (0.0020 × V_{eff})	0.6251 – (0.0019 × V_{eff})	0.6646 – (0.0017 × V_{eff})	0.7024 – (0.0013 × V_{eff})
2 (JSR)	0.3925 – (0.0020 × V_{eff})	0.6451 – (0.0019 × V_{eff})	0.7046 – (0.0017 × V_{eff})	0.7424 – (0.0013 × V_{eff})
3	0.4025 – (0.0020 × V_{eff})	0.6551 – (0.0019 × V_{eff})	0.7146 – (0.0017 × V_{eff})	0.7524 – (0.0013 × V_{eff})
4	0.5125 – (0.0020 × V_{eff})	0.7651 – (0.0019 × V_{eff})	0.8146 – (0.0017 × V_{eff})	0.8624 – (0.0013 × V_{eff})
5 (Max-Tech)	0.5725 – (0.0020 × V_{eff})	0.8251 – (0.0019 × V_{eff})	0.8746 – (0.0017 × V_{eff})	0.9224 – (0.0013 × V_{eff})

* No products exist in the very small draw pattern at the time of this analysis. DOE applied the differences in efficiency levels from the low draw pattern to define the Efficiency Levels 1 through 5 for the very small draw pattern.

Table IV.9 Oil-fired Storage: $V_{eff} \leq 50$ gal

Efficiency Level	UEF			
	Very Small*	**Low***	**Medium***	**High**
0 (Baseline)	0.2509 – (0.0012 × V_{eff})	0.5330 – (0.0016 × V_{eff})	0.6078 – (0.0016 × V_{eff})	0.6815 – (0.0014 × V_{eff})
1	0.2709 – (0.0012 × V_{eff})	0.5530 – (0.0016 × V_{eff})	0.6278 – (0.0016 × V_{eff})	0.7015 – (0.0014 × V_{eff})
2 (Max-Tech)	0.2909 – (0.0012 × V_{eff})	0.5730 – (0.0016 × V_{eff})	0.6478 – (0.0016 × V_{eff})	0.7215 – (0.0014 × V_{eff})

* No products exist in these draw patterns at the time of this analysis. DOE applied the differences in efficiency levels from the high draw pattern to define the Efficiency Levels 1 and 2 for the other draw patterns.

Table IV.10 Small Electric Storage: 20 gal $\leq V_{eff} \leq$ 35 gal, FHR < 51 gal

Efficiency Level	UEF	
	Very Small†	**Low**
0 (Baseline)	0.8808 – (0.0008 × V_{eff})	0.9254 – (0.0003 × V_{eff})
1 (JSR)	2.00*	2.00

* DOE applied the Joint Stakeholder Recommendation for low draw pattern units to the very small draw pattern in its analysis.
† No products exist in the very small draw pattern at the time of this analysis.

Table IV.11 Electric Storage: 20 gal $\leq V_{eff} \leq$ 55 gal, excluding Small Electric Storage

Efficiency Level	UEF			
	Very Small**	**Low**	**Medium**	**High**
0 (Baseline)	0.8808 – (0.0008 × V_{eff})	0.9254 – (0.0003 × V_{eff})	0.9307 – (0.0002 × V_{eff})	0.9349 – (0.0001 × V_{eff})
1 (JSR)	2.30*	2.30	2.30	2.30
2	3.2602 – (0.0008 × V_{eff}) †	3.3048 – (0.0003 × V_{eff})	3.3590 – (0.0002 × V_{eff})	3.4742 – (0.0001 × V_{eff})
3 (Max-Tech)	3.6602 – (0.0008 × V_{eff}) †	3.7048 – (0.0003 × V_{eff})	3.7590 – (0.0002 × V_{eff})	3.8742 – (0.0001 × V_{eff})

* DOE applied the Joint Stakeholder Recommendation for low draw pattern units to the very small draw pattern in its analysis.
** No products exist in the very small draw pattern at the time of this analysis.
† DOE applied the differences in efficiency levels from the low draw pattern to define the Efficiency Levels 2 and 3 for the very small draw pattern.

Table IV.12IVIV Electric Storage: 55 gal < $V_{eff} \leq$ 120 gal

Efficiency Level	UEF			
	Very Small**	**Low****	**Medium**	**High**
0 (Baseline)	1.9236 – (0.0011 × V_{eff})	2.0440 – (0.0011 × V_{eff})	2.1171 – (0.0011 × V_{eff})	2.2418 – (0.0011 × V_{eff})
1 (JSR)	2.50*	2.50	2.50	2.50
2	3.2198 – (0.0011 × V_{eff}) †	3.3402 – (0.0011 × V_{eff}) †	3.4133 – (0.0011 × V_{eff})	3.5380 – (0.0011 × V_{eff})
3 (Max-Tech)	3.7698 – (0.0011 × V_{eff}) †	3.8902 – (0.0011 × V_{eff}) †	3.9633 – (0.0011 × V_{eff})	4.0880 – (0.0011 × V_{eff})

* DOE applied the Joint Stakeholder Recommendation for low draw pattern units to the very small draw pattern in its analysis.
** Only one product exists in the low draw pattern at the time of this analysis. No products exist in the very small draw pattern at the time of this analysis.
† DOE applied the differences in efficiency levels from the medium draw pattern and high draw pattern to define the Efficiency Levels 2 and 3 for the very small draw pattern and the low draw pattern.

b. Design Options

Based on its teardown analyses and feedback provided by manufacturers in confidential interviews, DOE determined the technology options that are most likely to constitute the pathway to achieving the efficiency levels assessed. These technology options are referred to as “design options.” While manufacturers may achieve a given efficiency level using more than one design strategy, the selected design options reflect what DOE expects to be the most likely approach for the market in general in a standards-case scenario. Further details are provided in chapter 5 of the final rule TSD.

Ravnitzky indicated that DOE acknowledges that increased tank insulation can improve the efficiency of storage-type water heaters and questioned DOE's decision not to consider increased insulation thickness as a feasible technology option for electric storage water heaters. Ravnitzky claimed that, with sufficient insulation, non-heat pump water heaters can be nearly as efficient as heat pump water heaters. (Ravnitzky, No. 73 at p. 1)

DOE agrees that increased insulation thickness can improve the efficiency of storage-type water heaters and notes that increased insulation thickness is considered as a design option for increasing the efficiency of gas-fired and oil-fired storage water heaters. In addition, as discussed in the July 2023 NOPR, DOE initially considered an efficiency level for electric storage water heaters based on increased insulation thickness in the March 2022 Preliminary Analysis. However, in the July 2023 NOPR, DOE explained that in response to stakeholder feedback[38] on the March 2022 Preliminary Analysis, the first efficiency level design option for electric storage water heaters was changed to include heat pump technology, which DOE noted was more representative of the next level up from baseline. 88 FR 49058, 49089. Given the insulation thicknesses DOE has observed in models currently on the market, DOE maintains its position that the most likely design path for improving heat pump water heater efficiency above the baseline level would be through use of heat pump technology. Increasing insulation thicknesses to the point required to substantially increase the UEF of electric storage water heaters beyond what is required by the current standard may not be feasible. Therefore, for this final rule DOE has maintained the efficiency levels (and associated design options) for electric storage waters from the July 2023 NOPR.

In addition, DOE disagrees with the notion that non-heat pump water heaters could be made to be as efficient as heat pump water heaters through insulation thickness increases. Even if standby losses were to be completely eliminated, the electric resistance elements used for heating non-heat pump electric storage water heaters have a maximum theoretical efficiency of 100 percent, resulting in a maximum UEF of 1.00. Heat pump water heaters achieve efficiencies greater than 1.00 by extracting more heat energy from their surroundings than is required for them to operate, which non-heat pump water heaters are incapable of.

[38] Specifically, DOE explained that feedback from multiple sources indicated that increasing the thickness may not be practical in the manufacturing process because the R-value of polyurethane diminishes when the compound is blown into larger cavities, and the increase in thickness does not offset the increase in water heater surface area (which will increase standby losses).

BWC generally supported the design options DOE selected at the NOPR stage. (BWC, No. 1164 at p. 16) However, BWC reiterated its comments indicating that gas-fired storage water heaters can only use 1 inch of insulation in certain circumstances, and that it should not be considered as the baseline design option. BWC stated that 1 inch of insulation would not be capable of meeting the current standards, and only certain models designed to accommodate space constraints may come with 1 inch of insulation. The decreased insulation from 2 inches, BWC stated, has a drawback in lowering the FHR and recovery rate of the model. (BWC, No. 1164 at p. 17)

DOE believes that BWC may have misunderstood the design options that were modeled for the baseline efficiency level for gas-fired storage water heaters in the engineering analysis. Based on teardown analyses, DOE did determine that products with 1 inch of insulation can meet the existing standards, but only for the low draw pattern and the medium draw pattern.[39] At the NOPR stage, DOE took into account BWC's feedback about decreased FHRs and slower recovery rates. 88 FR 49058, 49094. These factors lead to gas-fired storage water heaters with only 1 inch of insulation also having smaller burners with lower input ratings. Products in the high draw pattern require larger burners. In the NOPR engineering analysis, DOE increased the insulation thickness for the high draw pattern designs of gas-fired storage water heaters. A thickness of 1.5 inches was used based on teardown samples of high draw pattern gas-fired storage water heaters at the representative size. *Id.* (*See* chapter 5 of the NOPR TSD.) However, this specifically pertained to side insulation. After reviewing BWC's comments and its own teardown samples, DOE has again updated the design option for high draw pattern gas-fired storage

[39] There are no gas-fired storage products certified within the very small draw pattern.

water heaters to use 1.5 inches of side insulation and 2 inches of top insulation to reflect the minimum amount of insulation necessary to meet the current standards.

Table IV.13 through Table IV.17 show the design options at each UEF level analyzed for this final rule. DOE maintained the design options as they were discussed in the July 2023 NOPR.

Table IV.13 - Design Options for Gas-fired Storage: 20 gal ≤ V_{eff} ≤ 55 gal

EL	**Standard and Low NOX** Design Options	**Ultra-Low NOX** Design Options
0	Standard burner; Standing pilot 1" side, 1" top insulation*; Cat I venting (atmospheric); Straight flue	Ultra-Low NO_X premix burner; Standing pilot 1" side, 1" top insulation*; Cat I venting (atmospheric); Straight flue
1	2" side, 2" top insulation	2" side, 2" top insulation
2A	Cat I venting (gas-actuated flue damper)	Cat I venting (gas-actuated flue damper)
2B	Electronic ignition; Cat I venting (electric flue damper)	Electronic ignition; Cat I venting (electric flue damper)
3	Electronic ignition Cat III venting (power venting) Increased heat exchanger baffling	Electronic ignition Cat III venting (power venting) Increased heat exchanger baffling
4	Cat IV venting (power venting) Condensing helical flue	Cat IV venting (power venting) Condensing helical flue
5	Increased heat exchanger surface area	Increased heat exchanger surface area
* 1.5” side / 2.0” top insulation was used for the high draw pattern		

Table IV.14 - Design Options for Oil-fired Storage: V_{eff} ≤ 50 gal

EL	Design Options
0	Single flue heat exchanger; Foam Insulation 1" side, 1.5" top insulation
1	Foam Insulation 2" side, 2.5" top insulation
2	Multi-flue heat exchanger

Table IV.15 - Design Options for Small Electric Storage: 20 gal ≤ V_{eff} ≤ 35 gal, FHR < 51 gal

EL	Design Options
0	3" side 3" top insulation; Lowboy aspect ratio (less than 36 inches in height)
1	Split-system R134A rotary compressor; Capillary expansion device; Counterflow condenser design; Tube-and-fin evaporator design; Shaded Pole Motor ("SPM") evaporator fan 2" side 2" top insulation

Table IV.16 - Design Options for Electric Storage: 20 gal ≤ V_{eff} ≤ 55 gal, excluding Small Electric Storage

EL	Design Options
0	3" side 3" top insulation; Short aspect ratio for products ≤ 35 gal or in the low draw pattern, tall aspect ratio for products > 35 gal and in the medium or high draw patterns
1	Integrated R134A rotary compressor; Capillary expansion device; Hotwall condenser; Tube-and-fin evaporator design; SPM evaporator fan 2" side 2" top insulation
2	Electronic expansion valve; Larger condenser; Larger evaporator; ECM evaporator fan
3	Larger condenser; Larger evaporator; Insulated sealed system; High efficiency fan blades

Table IV.17 - Design Options for Electric Storage: 55 gal < V_{eff} ≤ 120 gal

EL	Design Options
0	Integrated R134A rotary compressor; Electronic expansion valve; Hotwall condenser design; Tube-and-fin evaporator design; SPM evaporator fan 2" side 2" top insulation
1	Larger evaporator
2	Higher efficiency compressor; Larger condenser; Larger evaporator; ECM evaporator fan
3	Higher efficiency compressor; Larger condenser; Larger evaporator; High efficiency fan blades

c. Cost Analysis

The cost analysis portion of the engineering analysis is conducted using one or a combination of cost approaches. The selection of cost approach depends on a suite of factors, including the availability and reliability of public information, characteristics of the regulated product, the availability and timeliness of purchasing the product on the market. The cost approaches are summarized as follows:

- Physical teardowns: Under this approach, DOE physically dismantles a commercially available product, component-by-component, to develop a detailed bill of materials for the product.
- Catalog teardowns: In lieu of physically deconstructing a product, DOE identifies each component using parts diagrams (available from manufacturer websites or appliance repair websites, for example) to develop the bill of materials for the product.

- Price surveys: If neither a physical nor catalog teardown is feasible (for example, for tightly integrated products such as fluorescent lamps, which are infeasible to disassemble and for which parts diagrams are unavailable) or cost-prohibitive and otherwise impractical (e.g., large commercial boilers), DOE conducts price surveys using publicly available pricing data published on major online retailer websites and/or by soliciting prices from distributors and other commercial channels.

In this rulemaking, DOE utilizes a combination of the physical and catalog teardown approaches to develop estimates of the MPC at each UEF efficiency level analyzed. Data from the teardowns were used to create bills of materials ("BOMs") that capture all of the materials, components, and manufacturing processes necessary to manufacture products that achieve each UEF level. DOE used the BOMs along with publicly available material and component cost data as the basis for estimating the MPCs. DOE refined its cost estimates and its material and component cost data based on feedback received during confidential manufacturer interviews.

To perform this analysis, DOE selects representative capacities for each product class. These capacities reflect the most common or average size of a water heater in that product class, and this step is important because the MPC is dependent upon the size of the water heater—larger water heaters cost more to manufacture. The representative capacities analyzed in this rulemaking are detailed in chapter 5 of the final rule TSD. With the exception of one case, DOE has determined that the representative capacities analyzed in the July 2023 NOPR remain representative at this final rule stage. In this final rule analysis, DOE determined that a capacity of 75 gallons is more representative of units within the high draw pattern for electric storage water heaters in the 55–120-gallon range than 80 gallons, based on the distribution of units currently on the market (*see* appendix 3A to the final rule TSD). DOE therefore updated its analysis accordingly for this product class to use 75 gallons as the representative capacity.

In this rulemaking, DOE selected representative capacities for storage-type water heaters based on rated storage volume.

A.O. Smith agreed that heat pump water heaters are technologically feasible alternatives to electric resistance storage water heaters; however, A.O. Smith stated that 50-gallon heat pump water heaters are not always feasible replacements for 50-gallon electric resistance storage water heaters because, even for units with the same FHR, the heat pump offers a slower recovery that may not keep up with household demand. Additionally, A.O. Smith commented, homeowners must consider factors like ambient air temperature conditions when switching to a heat pump water heater, and it is often recommended to "upsize" when transitioning to a heat pump water heater so that performance expectations are not diluted. (A.O. Smith, No. 1182 at pp. 7–8)

DOE understands the commenter to be suggesting that, when evaluating the cost to improve efficiency, it may be more appropriate to consider representative capacities using a metric other than rated storage volume (*e.g.*, the FHR delivery capacity metric). The FHR determines which draw pattern a water heater falls into, and the engineering analysis selects representative characteristics for each draw pattern to determine cost and efficiency. While some consumers may opt to upsize when transitioning to heat pump water heaters, because the efficiency levels analyzed do not preclude designs with backup resistance heating elements, such "hybrid" heat pump water heaters can still achieve faster recoveries when the backup elements are used (the recovery rate of a backup element is independent of the ambient air conditions). Hence it would not be mandatory to upsize if installing a typical hybrid heat pump water heater. Thus, in this engineering analysis, DOE has maintained analysis points based on rated storage volume as opposed to other capacity metrics such as input rate or FHR. A separate consideration for maintaining the FHR is not necessary given the analysis is performed for each draw pattern separately. DOE did, however, perform a separate analysis to address the impact of ambient air conditions on heat pump water heater energy usage (*see* section IV.E of this document).

The results of DOE's cost-efficiency analysis for this final rule are shown in section IV.C.1.e of this document.

In response to the July 2023 NOPR, Rinnai pointed to a peer review report by the National Academy of Science, Engineering and Medicine ("NAS")[40] and stated that DOE's teardown analyses and cost reconstructions for existing products and newer high-efficiency designs is flawed and produces systematically underestimated costs (Rinnai suggested these costs were underestimated by roughly 30–50 percent). Rinnai stated that these underestimates to MPC lead to overstated LCC savings, and that DOE should instead look to market pricing to determine product cost or use market prices to validate other estimates. (Rinnai, No. 1186 at p. 33)

[40] National Academy of Science, Engineering and Medicine, "Review of Methods Used by the U.S. Department of Energy in Setting Appliance and Equipment Standards" (2021), ISBN 978-0-309-68545-0/DOI 10.17226/25992.

The rulemaking process for standards of covered products and equipment are outlined at appendix A to subpart C of 10 CFR part 430, and DOE periodically examines and revises these provisions in separate rulemaking proceedings. The recommendations in the NASEM report, which pertain to the processes by which DOE analyzes energy conservation standards, will be considered in a separate rulemaking considering all product categories.

As described in section IV.D of this document, under a more stringent standard, the mark-ups incorporated into the sales price may also change relative to current mark-ups. Therefore, DOE has concluded that basing the engineering analysis on prices of water heaters as currently seen in the marketplace would be a less accurate method of estimating future water heater prices following an amended standard than DOE's approach of conducting an engineering analysis and mark-ups analysis. (However, as noted earlier, price surveys are sometimes required when other methods are infeasible.) When relying on retail market data, the prices will include "premium" (*i.e.*, non-efficiency-related) features and do not account for the likely changes in designs, market, and pricing that would occur under an amended standard. Differences between online vendors with respect to mark-up and pricing practices could lead to online prices being unrepresentative for the overall market.

In response to the July 2023 NOPR, Rheem generally agreed with DOE's manufacturer production cost estimates, stating that they appeared reasonable for electric storage water heaters when the removal of non-efficiency related features and economies of scale are accounted for. (Rheem, No. 1177 at p. 8) BWC generally agreed with the gas-fired storage water heater manufacturer production cost estimates provided in the

July 2023 NOPR, but noted that the MPC estimates for electric storage water heaters were inconsistent with its experience. BWC stated that it would welcome further opportunities to discuss this specific matter confidentially with DOE for this rulemaking. (BWC No. 1164 at p. 17)

As discussed in the July 2023 NOPR, DOE's consultants routinely conduct confidential manufacturer interviews to gather feedback on various analytical inputs, which are then aggregated for use in the analysis. Cost analyses are updated based on feedback where appropriate. 88 FR 49058, 49095. In addition, due to the volatility of metal prices, DOE uses 5-year average metal prices to minimize the impact of large fluctuations in metal prices. *Id*. DOE's 5-year average metal cost data have been updated to reflect prices for the most recent 5-year period ending August 2023. For all other material and component prices, DOE used the most recent prices available at the time of the analysis (*i.e.*, August 2023). As discussed, the MPC estimates used in this rulemaking reflect what would be the market-average product cost to manufacture a model that meets the efficiency level, excluding the cost of optional features that do not affect the efficiency of the product, and these estimates take into account what the designs and component costs would be in a standards-case-scenario. Because the metal prices used may deviate from the most recent year's and because the designs modeled reflect market averages in a standards-case-scenario without optional non-efficiency-related components, the MPC estimates resulting from this analysis may not exactly reflect the designs of any one specific manufacturer today.

d. Shipping Costs

Shipping costs for storage-type consumer water heater product classes were determined based on the area of floor space occupied by the unit, including packaging, and the weight. Most consumer water heaters cannot be shipped in any orientation other than vertical and are too tall to be double-stacked in a vertical fashion, though some units analyzed by DOE can be double-stacked. For small units that can be double-stacked, including lowboy electric storage water heaters and non-lowboy electric storage water heaters less than or equal to 35 gallons in storage volume, the floor area available effectively doubles, reducing the overall shipping cost compared to taller products. DOE also accounted for electric storage water heaters sold as split-system heat pumps stacking the heat pump assembly atop the tank assembly. DOE research suggests that consumer water heaters are usually shipped together in nearly fully loaded trailers, rather than in less than truckload ("LTL") configurations, where the consumer water heaters only occupy a portion of the trailer volume. Therefore, shipping costs have been calculated assuming fully loaded trailers; however, DOE applied an assumption that each truckload would only consist of one type of water heater, which may result in a conservative estimate of shipping costs.

To calculate the shipping costs, DOE estimated the cost per trailer based on standard trailer sizes, shipping the products between the middle of the country to the coast, using the most recent reference year for prices (*i.e.*, 2022 for the July 2023 NOPR and 2023 for this final rule). Next, DOE estimated the shipped size (including packaging) of products in each product class at each efficiency level and, for each product class and efficiency level, determined the number of units that would fit in a trailer. DOE then calculated the average shipping cost per unit by dividing the cost per trailer load by the number of units that would fit per trailer (based on a calculation of whether the quantity is limited by space or by weight), for each product class and efficiency level.

In the July 2023 NOPR, DOE requested feedback on the analysis assumptions used to estimate shipping costs for consumer water heaters.

BWC stated that the shipping cost estimates provided in the July 2023 NOPR were generally consistent with its expectations, and that it is correct to assume that water heaters typically do not ship in less-than-truckload configurations; however, real-world circumstances (such as one truck delivering orders to multiple wholesalers) prevent truckloads from consisting of solely one type of water heater. (BWC, No. 1164 at p. 18) However, BWC did not agree with the Department's assumption that each truckload would only consist of one type of water heater. In their experience this rarely occurs since truckloads are scheduled to fulfill multiple orders from multiple customers who are rarely ordering identical products. (BWC No. 1164 at p. 18)

DOE agrees with BWC that manufacturers do not always ship trucks completely full of one type of water heater. The shipping costs in the real world vary with a multitude of factors that are difficult to model and predict. For storage-type water heaters that are shipped with tankless water heaters, DOE expects the shipping costs it assumed to be conservatively high, because the estimate is based on a truck full of only storage-type water heaters (which would, as a result, not be able to carry as many products due to the size of the storage-type water heaters).

After considering the feedback received on shipping costs, DOE maintained the methodology from the July 2023 NOPR for this final rule but updated the cost per trailer using the most recent data available. The shipping costs are shown in section IV.C.1.e of this document.

e. Cost-Efficiency Results

The results of the engineering analysis are reported as cost-efficiency data in the form of MPCs and shipping costs calculated for each efficiency level of each product class for which DOE is proposing amended UEF-based standards. As discussed previously, DOE determined these costs by developing BOMs based on a combination of physical and catalog teardowns and using information in the BOMs along with component and material price data to estimate MPCs.

For heat pump water heaters specifically, BWC urged the Department to consider price impacts related to the Federal American Innovation and Manufacturing ("AIM") Act of 2020, codified at 42 U.S.C. 7675. BWC noted that this legislation calls for a gradual phasedown of refrigerant products that are currently predominant in heat pump water heater designs, and stated that the provisions in the AIM Act will compel manufacturers to pivot to more costly refrigerants when producing heat pump water heater products. (BWC No. 1164 at p. 18)

In response, DOE notes that the AIM Act authorizes EPA to address hydrofluorocarbons ("HFCs") in three main ways: phasing down HFC production and consumption through an allowance allocation program; promulgating certain regulations for purposes of maximizing reclamation and minimizing releases of HFCs from equipment; and facilitating sector-based transitions to next-generation technologies. (*See* 42 U.S.C. 7675) Regarding the gradual phasedown of HFC refrigerants with high global warming potential ("GWP"), the AIM Act mandates the phasedown of HFCs by 85 percent over a period ending in 2036, following the schedule outlined in the AIM Act. (42 U.S.C. 7675(e)(2)(C)) DOE notes that the engineering analysis incorporates up-to-date cost estimates (including the cost of refrigerants currently used in heat pump water heaters).

For this final rule, DOE reviewed EPA rulemakings pertaining to the phasedown of HFC production and consumption and sector-based transitions to next-generation technologies. Regarding the sector-based transitions under subsection (i) of the AIM Act, EPA published a final rule restricting the use of HFCs in specific sectors or subsectors on October 24, 2023 ("October 2023 EPA Final Rule"). 88 FR 73098. In the October 2023 EPA Final Rule, EPA does not adopt provisions to restrict the use of high-GWP refrigerants in heat pump water heaters. DOE understands that manufacturers may voluntarily invest in low-GWP systems for future heat pump water heater designs, however, such systems would not be mandatory as a result of Federal regulation at this time. However, the October 2023 EPA Final Rule does restrict the use of HFCs and blends containing HFCs with a GWP of 150 or greater beginning January 1, 2025 for all foam subsectors, including rigid polyurethane for use in water heaters. 88 FR 73098, 73183-73184. As discussed in chapter 3 of the final rule TSD, DOE has found that water heater manufacturers have already begun transitioning to alternative blowing agents for insulation foam, therefore this regulation is not expected to impact manufacturer production costs for consumer water heaters.

DOE maintained the same methodology as the July 2023 NOPR to develop the cost-efficiency results for this final rule, as detailed in section IV.C.1.c of this document. The results of DOE's analysis are listed in Table IV.18 through Table IV.23.

See chapter 5 of the final rule TSD for more details concerning these results.

Table IV.18 - Engineering Analysis Results for Gas-fired Storage: 20 gal ≤ V_{eff} ≤ 55 gal, Standard and Low NO_X

EL	UEF				MPC (2022$)	Shipping (2022$)
	Very Small	Low 29 gal	Medium 38 gal	High 48 gal		
0	N/A	0.54	0.58	0.63	Low: 172.98 Med: 197.89 High: 227.72	Low: 25.67 Med: 28.43 High: 42.45
1	N/A	0.57	0.60	0.64	Low: 189.41 Med: 215.70 High: 236.99	Low: 28.43 Med: 30.61 High: 44.22
2A	N/A	0.59	0.64	0.68	Low: 243.26 Med: 269.55 High: 290.85	Low: 28.43 Med: 30.61 High: 44.22
2B	N/A	0.59	0.64	0.68	Low: 277.73 Med: 303.77 High: 324.76	Low: 28.43 Med: 30.61 High: 44.22
3	N/A	0.60	0.65	0.69	Low: 290.19 Med: 316.40 High: 338.00	Low: 28.43 Med: 30.61 High: 44.22
4	N/A	0.71	0.75	0.80	Low: 372.91 Med: 398.70 High: 426.00	Low: 28.43 Med: 30.61 High: 44.22
5	N/A	0.77	0.81	0.88	Low: 385.61 Med: 415.61 High: 447.15	Low: 30.61 Med: 44.22 High: 48.24

Table IV.19 - Engineering Analysis Results for Gas-fired Storage: 20 gal ≤ V_{eff} ≤ 55 gal, Ultra Low NO_X

EL	UEF				MPC (2022$)	Shipping (2022$)
	Very Small	Low 29 gal	Medium 38 gal	High 48 gal		
0	N/A	0.54	0.58	0.63	Low: 256.02 Med: 286.10 High: 322.46	Low: 25.67 Med: 28.43 High: 42.45
1	N/A	0.57	0.60	0.64	Low: 272.76 Med: 304.67 High: 331.85	Low: 28.43 Med: 30.61 High: 44.22
2A	N/A	0.59	0.64	0.68	Low: 326.61 Med: 358.52 High: 385.70	Low: 28.43 Med: 30.61 High: 44.22
2B	N/A	0.59	0.64	0.68	Low: 361.08 Med: 392.82 High: 419.69	Low: 28.43 Med: 30.61 High: 44.22
3	N/A	0.60	0.65	0.69	Low: 377.03 Med: 409.28 High: 436.57	Low: 28.43 Med: 30.61 High: 44.22
4	N/A	0.71	0.75	0.80	Low: 451.23 Med: 481.31 High: 513.03	Low: 28.43 Med: 30.61 High: 44.22
5	N/A	0.77	0.81	0.88	Low: 463.93 Med: 498.22 High: 534.19	Low: 30.61 Med: 44.22 High: 48.24

Table IV.20 - Engineering Analysis Results for Oil-fired Storage: V_{eff} ≤ 50 gal

EL	UEF				MPC (2022$)	Shipping (2022$)
	Very Small	Low	Medium	High 30 gal		
0	N/A	N/A	N/A	0.64	893.59	30.61
1	N/A	N/A	N/A	0.66	922.63	44.22
2	N/A	N/A	N/A	0.68	1003.56	44.22

Table IV.21 - Engineering Analysis Results for Small Electric Storage: 20 gal ≤ V_{eff} ≤ 35 gal, FHR < 51 gal

EL	UEF			MPC (2022$) Draw Pattern ($V_{eff}$)	Shipping, (2022$) Draw Pattern ($V_{eff}$)
	Very Small	Low 26 gal	Low 35 gal		
0	N/A	0.92	0.91	Low (26): 149.92 Low (35): 176.41	Low (26): 16.08 Low (35): 25.27
1	N/A	2.00	2.00	Low (26): 523.46 Low (35): 547.91	Low (26): 48.24 Low (35): 50.53

Table IV.22 - Engineering Analysis Results for Electric Storage: 20 gal ≤ V_{eff} ≤ 55 gal, excluding Small Electric Storage

EL	UEF						MPC (2022$) Draw Pattern ($V_{eff}$)	Shipping (2022$) Draw Pattern ($V_{eff}$)
	Very Small	Low 36 gal	Medium 30 gal	Medium 36 gal	Medium 45 gal	High 55 gal		
0	N/A	0.91	0.92	0.92	0.92	0.93	Low (36): 175.16 Med (30): 162.38 Med (36): 178.62 Med (45): 192.16 High (55): 207.87	Low (36): 42.45 Med (30): 22.11 Med (36): 29.48 Med (45): 30.61 High (55): 46.14
1	N/A	2.30	2.30	2.30	2.30	2.30	Low (36): 419.80 Med (30): 405.14 Med (36): 421.36 Med (45): 436.17 High (55): 446.41	Low (36): 42.45 Med (30): 44.22 Med (36): 29.48 Med (45): 30.61 High (55): 46.14
2	N/A	3.29	3.35	3.35	3.35	3.47	Low (36): 445.22 Med (30): 432.13 Med (36): 446.75 Med (45): 461.48 High (55): 479.57	Low (36): 42.45 Med (30): 44.22 Med (36): 29.48 Med (45): 30.61 High (55): 46.14
3	N/A	3.69	3.75	3.75	3.75	3.87	Low (36): 496.68 Med (30): 478.86 Med (36): 495.06 Med (45): 512.85 High (55): 526.86	Low (36): 42.45 Med (30): 44.22 Med (36): 29.48 Med (45): 30.61 High (55): 46.14

Table IV.23 Engineering Analysis Results for Electric Storage: 55 gal < V_{eff} ≤ 120 gal

EL	UEF				MPC (2022$)	Shipping (2022$)
	Very Small	Low	Medium 58 gal	High 75 gal		
0	N/A	N/A	2.05	2.15	Med: 466.55 High: 493.93	Med: 44.22 High: 48.24
1	N/A	N/A	2.50	2.50	Med: 473.18 High: 498.43	Med: 44.22 High: 48.24
2	N/A	N/A	3.35	3.45	Med: 498.33 High: 515.77	Med: 44.22 High: 48.24
3	N/A	N/A	3.90	4.00	Med: 559.99 High: 576.94	Med: 44.22 High: 48.24

2. Product Classes Without Current UEF-Based Standards

In the December 2016 Conversion Factor Final Rule, DOE established that EF-based standards as established by EPCA are applicable to consumer water heaters but would not be enforced until conversion factors and converted standards are adopted. 81 FR 96204, 96209-96211. To convert these EF-based standards to UEF-based standards, DOE first developed conversion factors that convert tested values measured under the DOE test procedure in effect prior to the July 2014 TP Final Rule (which produces the EF metric) to values found under the current DOE test procedure (which produces the UEF metric). DOE then applied these conversion factors to representative baseline models and derived the UEF-based energy conservation standards from the resulting UEF values.

For the July 2023 NOPR, DOE applied a similar methodology to translate from minimum efficiency levels denominated in EF to those in UEF for classes of covered consumer water heaters that do not yet have UEF-based standards. The translated standards are shown in Table IV.24.

Table IV.24 Translated UEF-based Energy Conservation Standards for Product Classes without established UEF-based Standards

Product Class	Nominal Input	Effective Storage Volume	Draw Pattern	Uniform Energy Factor
Gas-fired Storage Water Heater	≤ 75,000 Btu/h	< 20 gal	Very Small	$0.2062 - (0.0020 \times V_{eff})$
			Low	$0.4893 - (0.0027 \times V_{eff})$
			Medium	$0.5758 - (0.0023 \times V_{eff})$
			High	$0.6586 - (0.0020 \times V_{eff})$
		> 100 gal	Very Small	$0.1482 - (0.0007 \times V_{eff})$
			Low	$0.4342 - (0.0017 \times V_{eff})$
			Medium	$0.5596 - (0.0020 \times V_{eff})$

Product Class	Nominal Input	Effective Storage Volume	Draw Pattern	Uniform Energy Factor
			High	0.6658 - (0.0019 x V_{eff})
Oil-fired Storage Water Heater	≤ 105,000 Btu/h	> 50 gal	Very Small	0.1580 - (0.0009 x V_{eff})
			Low	0.4390 - (0.0020 x V_{eff})
			Medium	0.5389 - (0.0021 x V_{eff})
			High	0.6172 - (0.0018 x V_{eff})
Electric Storage Water Heaters	≤ 12 kW	< 20 gal	Very Small	0.5925 - (0.0059 x V_{eff})
			Low	0.8642 - (0.0030 x V_{eff})
			Medium	0.9096 - (0.0020 x V_{eff})
			High	0.9430 - (0.0012 x V_{eff})
		> 120 gal	Very Small	0.3574 - (0.0012 x V_{eff})
			Low	0.7897 - (0.0019 x V_{eff})
			Medium	0.8884 - (0.0017 x V_{eff})
			High	0.9575 - (0.0013 x V_{eff})
Tabletop Water Heater	≤ 12 kW	< 20 gal	Very Small	0.5925 - (0.0059 x V_{eff})
			Low	0.8642 - (0.0030 x V_{eff})
Instantaneous Oil-fired Water Heater	≤ 210,000 Btu/h	< 2 gal	Very Small	0.61
			Low	0.61
			Medium	0.61
			High	0.61
		≥ 2 gal	Very Small	0.2780 - (0.0022 x V_{eff})
			Low	0.5151 - (0.0023 x V_{eff})
			Medium	0.5687 - (0.0021 x V_{eff})
			High	0.6147 - (0.0017 x V_{eff})
Instantaneous Electric Water Heater	≤ 12 kW	≥ 2 gal	Very Small	0.8086 - (0.0050 x V_{eff})
			Low	0.9123 - (0.0020 x V_{eff})
			Medium	0.9252 - (0.0015 x V_{eff})
			High	0.9350 - (0.0011 x V_{eff})

a. Crosswalk to Equivalent-Stringency UEF-Based Standards

In the July 2023 NOPR, DOE requested feedback regarding the appropriateness of the proposed converted UEF-based standards and whether products on the market can meet or exceed the proposed levels. 88 FR 49058, 49100.

A.O. Smith noted that DOE initially proposed UEF levels for several of these classes in the supplemental notice of proposed rulemaking published on August 30, 2016 ("August 2016 Conversion Factor SNOPR"). 81 FR 59736 DOE, however, decided to forgo adopting the proposed levels for these classes in the December 2016 Conversion Factor Final Rule. A.O. Smith stated that DOE wrote it "Received voluminous comments regarding the technical merits of the conversion factors and the converted standards expressed in UEF for the water heaters listed in Table III.1 for which DOE is going to defer finalizing and implementing these statutory standards and further consider the comments."[41] A.O. Smith reiterated its comments submitted in response to the August 2016 SNOPR.[42] Throughout the July 2023 NOPR TSD, DOE notes that for most of the product classes being converted, there are currently no models on the market, and therefore it did not use test data to adjust its analytical model. However, there are products on the market that comport to several of the product classes for which DOE has proposed UEF energy conservation standard levels. (A.O. Smith, No. 1182 at p. 11)

In the August 2016 Conversion Factor SNOPR, DOE explained that it had considered the applicability of standards to the products which eventually did not receive

[41] *See* 81 FR 96204, 96211.
[42] Found online at: *www.regulations.gov/comment/EERE-2015-BT-TP-0007-0028* .

UEF-based standards because these products were not considered in DOE's rulemakings that culminated in the April 16, 2010 and January 17, 2001 final rules (75 FR 20112 and 66 FR 4474, respectively), and accordingly, the standards adopted in those final rules are not applicable to these products. 81 FR 59736, 59742. Hence, the statutory EF-based standards were deemed most applicable to these product classes. *Id.* A.O. Smith generally raised the concern of needing test data to validate the converted standards when responding to the August 2016 Conversion Factor SNOPR, but did not explicitly indicate that the conversion equations were incorrect for the products which did not get converted. Rather, A.O. Smith had iterated that it was inappropriate at the time to establish standards without the basis of a test procedure that covered the sizes of water heaters in question. (A.O. Smith, EERE-2015-BT-TP-0007-0028 at pp. 2-3) As of the June 2023 TP Final Rule, the appendix E test procedure does cover all of the consumer water heaters being addressed in this analysis, and it is clearly established which EF-based standards do apply to these products.

Rheem supported DOE’s methodology to conduct the EF to UEF crosswalk for electric storage water heaters and gas-fired storage water heaters that currently do not have UEF-based standards. (Rheem, No. 1177 at p. 9-11) Other commenters requested that DOE publish data to demonstrate that the crosswalk results in appropriate standards compared to how these products would be rated if tested to the UEF test procedure.

A.O. Smith emphasized that DOE must have test data to demonstrate that the crosswalked UEF standards are achievable by products on the market today, especially for very small electric storage water heaters, where there are several models on the market. A.O. Smith noted that previous experience with test procedure changeovers has shown that new test methods and test metrics impact water heaters differently and often unpredictably depending upon their specific attributes. The commenter indicated that it conducted its own testing and provided a limit set of results showing that very small electric storage water heaters could pass the crosswalked standards at a normal temperature setpoint. (A.O. Smith, No. 1182 at pp. 11-12)

NYSERDA noted that the crosswalked product classes begin with the statutory EF standards, which result in the converted standards being significantly lower than those proposed for products with current UEF standards. (NYSERDA, No. 1192 at pp. 4-5) NYSERDA commented that, when the conversion factors were developed, these equations did not apply to the products that DOE is crosswalking to UEF standards in this rulemaking. (NYSERDA, No. 1192 at p. 5) Additionally, NYSERDA stated that the conversion factors were developed using rated storage volume; therefore the converted standards should be in rated storage volume also (instead of effective storage volume). (NYSERDA, No. 1192 at p. 5) NYSERDA recommended two approaches for setting standards for the product classes where there are no current models: a first option would be to test similarly sized products that do exist on the market; otherwise, the volume thresholds can be removed. NYSERDA commented that if DOE determines that these converted standards require additional analysis, it could simply clarify in the final rule that these products are still subject to the statutory EF standards and continue to rely on the waiver process to accommodate any products introduced within these categories; however, the commenter still encouraged DOE to further examine the converted EF standards. (NYSERDA, No. 1192 at p. 5)

Bosch stated there is insufficient information to fully justify the proposed converted UEF values for the very small electric storage water heater product class, adding that the 2016 Conversion Factor Final Rule was not originally intended for this product group. Bosch requested DOE release its analysis of the efficiency testing conducted on the 17 models in this product class, as there are significant differences between tanks and element types within this product class. (Bosch, No. 1204 at pp. 3–4)

BWC expressed concerns regarding the EF-to-UEF crosswalk DOE has analyzed in this rulemaking. BWC stated that using the December 2016 Conversion Factor Final Rule equations to establish UEF-based standards for these products is not appropriate because these products were never subjected to the EF test procedure, and that DOE's approach in the March 2022 Preliminary Analysis and July 2023 NOPR could set an improper baseline. (BWC, No. 1164 at p. 10)

As discussed in the July 2023 NOPR TSD, DOE conducted its own testing to verify that products on the market, when tested to the appendix E test procedure, would comply with the crosswalked standards. In response to the numerous requests for additional test data, DOE has published the results of the testing in chapter 5 of the final rule TSD. Additionally, DOE notes that A.O. Smith's test data also indicates that the standards are achievable (so long as the high temperature test is not used, which results in lower ratings). As discussed in section V.D.1, DOE has determined not to subject very small electric storage water heaters to high temperature testing; therefore, this would not be expected to reduce their UEF to a level below the adopted standards.

DOE notes that during the 2016 Conversion Factor rulemaking, it conducted testing of 55 consumer storage water heaters and 22 consumer instantaneous water heaters to validate the conversion factors used to determine the UEF-based standards DOE is establishing in this rulemaking. In addition, AHRI provided data for 130 consumer storage water heaters and 36 consumer instantaneous water heaters using both EF and UEF test procedures.[43] 81 FR 96204, 96214-96216. DOE concluded that these conversion factors resulted in UEF-based standards that were neither more nor less stringent than the equivalent EF-based standards. 81 FR 96204, 96207.

Rheem supported the translated UEF standards for very small electric storage water heaters, but recommended that DOE remove the high draw and medium draw pattern standards for very small electric storage water heaters because these levels are generally not achievable or necessary. (Rheem, No. 1177 at p. 9)

Removing the high and medium draw pattern standards for very small electric storage water heaters would result in a gap in coverage of standards, however, should products meeting this description become available in the future. Therefore, DOE is maintaining its approach to adopt standards for each draw pattern for very small electric storage water heaters. Should more data become available after this rulemaking, DOE may consider consolidating standards for different draw patterns if it can be determined conclusively that the medium and high draw pattern standards are not justified.

[43] Data for consumer water heaters tested during the development of the 2016 Conversion Factor Final Rule were reported in an SNOPR published in the *Federal Register* on August 30, 2016. 81 FR 59736.

Rheem added further that reducing the crosswalked electric instantaneous water heater standards to align with those for very small electric storage water heaters would reduce manufacturer burden and design costs. (Rheem, No. 1177 at pp. 13–14)

While DOE acknowledges that electric instantaneous water heaters and very small electric storage water heaters may be installed in similar applications, as discussed in section IV.A.1.c of this document, storage-type and instantaneous-type water heaters generally have differences in operation that can lead to different utilities. Hence, DOE is maintaining its approach to treat these as separate product classes and evaluate standards separately.

BWC provided that it did not believe an approach that relied on a market analysis of currently listed models, along with an efficiency level and design option (teardown) analysis, was appropriate for these product classes that did not previously have a minimum efficiency standard. BWC stated that accounting for the stored water temperature and rated storage volume largely influence a product's efficiency rating, but there are other factors that can strongly influence the UEF, such as insulation thickness (for electric-type storage water heaters) and modulating controls (for instantaneous water heaters). BWC thus requested DOE to docket the analysis conducted to establish the new minimum UEF levels for these product classes. (BWC, No. 1164 at p. 10)

For this final rule DOE maintains its approach for converting standards from EF to UEF. EPCA directed DOE to establish a uniform efficiency descriptor to be used to regulate all covered water heaters, with certain exceptions for water heaters used only in commercial applications. (42 U.S.C. 6295I(5)) Therefore, DOE has conducted this analysis in satisfaction of its statutory obligation to delineate standards for all consumer water heaters in terms of UEF. The statute provides that, in the case of a test procedure or metric change, DOE must determine what equivalent standards are on the basis of the new test procedure or metric. (42 U.S.C. 6293(e)(2)) The conversion factor calculations serve to accomplish this purpose. Because the UEF-based standards for these product classes reflect the same stringency as the statutory EF-based standards that are currently applicable—*i.e.*, these are not standards that would require higher efficiency to comply—it is not necessary for DOE to conduct an assessment of energy savings or economic justification prior to proposing such standards. The Department believes that BWC may have misinterpreted the analysis for product classes with current UEF-based standards as also applying to these product classes which have EF-based standards. To reiterate, these standards are not being established pursuant to EPCA provisions at 42 U.S.C. 6295(o)(A), but instead in accordance with those at 42 U.S.C. 6293(e)(2). Additionally, the statutory EF-based standards are provided within EPCA and do not require separate justification to adopt these stringencies.

b. Consideration of More Stringent Standards

DOE also requested information and data regarding the UEF of products within these product classes if they are found to generally exceed the proposed levels. 88 FR 49058, 49100.

BWC supported DOE's tentative determination not to propose more stringent standards for product classes that are currently covered by the statutory EF-based standards because these product classes have low market share and would present limited opportunity for energy savings. (BWC, No. 1164 at p. 3)

Rheem commented that there may be no or very few water heaters on the market in the volume ranges for which crosswalked standards were proposed for gas-fired storage water heaters and therefore did not support more stringent standards for these sizes of gas-fired storage water heaters. (Rheem, No. 1177 at p. 11)

Rheem recommended against increasing the > 120-gallon standards for electric storage water heaters to a level that would require heat pump technology because ASME tank construction is required for water heaters with a measured volume > 120 gallons, significantly increasing the cost of the water heater to the point where it is not a low-cost replacement for a heat pump water heater. (Rheem, No. 1177 at p. 10) However, Rheem recommended increasing the energy conservation standards for < 20-gallon tabletop water heaters to the levels proposed for ≥ 20-gallon tabletop water heaters and simplifying the energy conservation standards table. (Rheem, No. 1177 at p. 10)

In general, while there are few (or sometimes no) models on the market that fall within these product classes, comments received in response to the July 2023 NOPR suggested that, within the 5-year compliance period of this final rule, manufacturers would be incentivized to develop new models in these product classes in lieu of developing designs for product classes with current UEF-based standards that have to comply with more stringent standards. Based on the comments, which are summarized in the following paragraphs, DOE understands that this is possible if the design changes required to transfer an existing model to a product class without current UEF-based standards are less expensive than the design changes required to increase the efficiency of that model to meet the amended standard for the product class with a current UEF-based standard. Commenters provided feedback on whether or not more stringent standards were justified based on whether or not the product class could be used to "circumvent" other standards for similar product classes that have higher standards.

A.O. Smith indicated that simultaneous establishment of baseline UEF levels for converted product classes while increasing the efficiency levels for existing product classes creates a scenario where new products may emerge, and shipments may shift from product classes with more stringent standards to very similar products in new product classes with less stringent standards. (A.O. Smith, No. 1182 at p. 14)

DOE does not currently possess data supporting more stringent standards than those being established as part of this rulemaking. However, DOE may conduct a separate rulemaking to determine the benefits and burdens of higher standards for these products at a later time. For example, after the compliance date of this final rule, the availability of certifications of UEF may enable DOE to consider more stringent standards in a future rulemaking.

A.O. Smith provided some test data for very small electric storage water heaters showing that these products would not pass the proposed standards when tested to the high temperature test method, and thus recommended that very small electric storage water heaters be exempt from the high temperature test method. A.O. Smith stated that this test method would not be representative of an average use cycle for very small electric storage water heaters, and the company would rather dedicate its engineering resources toward the development of future heat pump offerings rather than redesigning existing product lines for modest efficiency gains resulting from overlapping test procedure changeovers. A.O. Smith recommended DOE test baseline very small and small electric storage water heaters according to the proposed test procedure to ensure that crosswalked standards do not result in a stringency increase. (A.O. Smith, No. 1182 at pp. 11-12)

Rheem recommended against setting a standard for very small electric storage water heaters at any higher stringency because a forced redesign for these products may not be necessary and would divert manufacturers' resources away from the heat pump water heater innovation. (Rheem, No. 1177 at p. 9)

DOE understands that, if the high temperature test method were to apply to very small electric storage water heaters, then that test method would result in lower efficiency ratings for these products, and these lower ratings would not comply with the crosswalked standards. Therefore, manufacturers would have to redesign very small electric storage water heaters to be more efficient in order to comply with the standards that resulted from the EF-to-UEF crosswalk, and this would effectively constitute an increase in stringency of standards for these products. In section V.D.1.c of this document, DOE explains its determination to exempt very small electric storage water heaters from the high temperature test. As a result, there would be no increase to stringency for these products.

c. Circulating Water Heaters

Prior to the publication of the June 2023 TP Final Rule, the test procedure did not provide sufficient clarity regarding how circulating water heaters should be tested, and the June 2023 TP Final Rule established a new method of testing circulating water heaters with separate storage tanks (*see* section 4.10 of appendix E) to represent how these products are used in the field. As a result of this method of testing, the efficiency ratings for circulating water heaters will reflect the standby losses incurred by the separate storage tank. As discussed previously in section IV.A.1.a of this document, DOE is classifying circulating water heaters as storage-type water heaters subject to the storage water heaters standards. In the July 2023 NOPR, however, DOE considered circulating water heaters as instantaneous water heaters and developed proposed standards using the instantaneous water heater efficiency levels as a starting point.

In response to the levels proposed in the July 2023 NOPR, NYSERDA suggested that DOE could address more stringent, heat pump-level standards for electric circulating water heaters in a separate rulemaking to ensure that the energy savings from this rulemaking are realized. (NYSERDA, No. 1192 at p. 7)

BWC requested clarification on how DOE derived the minimum efficiency levels for electric circulating water heaters in the NOPR, noting that the efficiencies corresponded to electric resistance technology, not heat pump circulating water heaters. (BWC, No. 1164 at pp. 2–3)

As discussed in section IV.A.1.a of this document, circulating water heaters will be subject to the applicable standards for storage-type water heaters. As such, there is no separate analysis to address UEF-based standards for circulating water heaters in this final rule.

In response to the December 2023 SNOPR proposing to treat circulating water heaters as part of the storage-type water heater product classes, BWC claimed that establishing heat pump-level standards for electric circulating water heaters would be inappropriate because they would favor one design option over another, as heat pump water heaters are not considered a separate product class from electric storage water heaters, stating that EPCA requires DOE to determine standards without regards to the technologies utilized by manufacturers or preferred by consumers. BWC requested that DOE clarify its understanding of its authority under EPCA with respect to these standards. (BWC, No. 1413 at pp. 2-3)

DOE notes that the analysis conducted in this rulemaking has determined that the amended standards for electric storage water heaters (which include electric circulating water heaters) are both technologically feasible and economically justified, and result in significant savings. These conclusions are discussed in detail in section V.C.1 of this document. DOE uses the screening criteria found in Sections 6(b)(3) and 7(b) of appendix A to 10 CFR part 430, subpart C to determine which technology options are suitable for further consideration in an energy conservation standards rulemaking. Under the criteria for technological feasibility, DOE considers technologies incorporated in commercially-available products or in working prototypes to be technologically feasible. As such, EPCA does not prohibit DOE from establishing a standard that can only be met through the use of a certain technology. Heat pump technology is the only technology available to allow electric circulating water heaters to achieve higher efficiency levels.

DOE is not establishing a prescriptive design requirement that electric circulating water heaters must implement heat pump technology.

3. Manufacturer Selling Price

To account for manufacturers' non-production costs and profit margin, DOE applies a multiplier (the manufacturer markup) to the MPC. The resulting manufacturer selling price ("MSP") is the price at which the manufacturer distributes a unit into commerce. DOE developed an average manufacturer markup by examining the annual Securities and Exchange Commission ("SEC") 10-K[44] reports filed by publicly traded manufacturers that produce consumer water heaters, the manufacturer markups from the April 2010 Final Rule, and feedback from confidential manufacturer interviews. 75 FR 20112. *See* chapter 12 of the final rule TSD for additional detail on the manufacturer markup.

D. Markups Analysis

The markups analysis develops appropriate markups (*e.g.*, retailer markups, distributor markups, contractor markups) in the distribution chain and sales taxes to convert the MSP estimates derived in the engineering analysis to consumer prices, which are then used in the LCC and PBP analysis. At each step in the distribution channel, companies mark up the price of the product to cover business costs and profit margin.

[44] U.S. Securities and Exchange Commission. Company Filings. Available at*www.sec.gov/edgar/searchedgar/companysearch.html* (last accessed December 1, 2023).

For consumer water heaters, the main parties in the distribution chain are (1) manufacturers, (2) wholesalers or distributors, (3) retailers, (4) plumbing contractors, (5) builders, (6) manufactured home manufacturers, and (7) manufactured home dealers/retailers. *See* chapter 6 and appendix 6A of the final rule TSD for a more detailed discussion about parties in the distribution chain.

For this final rule, DOE characterized how consumer water heater products pass from the manufacturer to residential and commercial consumers[45] by gathering data from several sources, including consultant reports (available in appendix 6A of the final rule TSD), the 2023 BRG report,[46] and the 2022 Clear Seas Research Water Heater contractor survey[47] to determine the distribution channels and fraction of shipments going through each distribution channel. The distribution channels for replacement or new owners of consumer water heaters in residential applications (not including mobile homes) are characterized as follows:[48]

Manufacturer ➔ Wholesaler ➔ Plumbing Contractor ➔ Consumer

Manufacturer ➔ Retailer ➔ Consumer

Manufacturer ➔ Retailer ➔ Plumbing Contractor ➔ Consumer

[45] DOE estimates that 2 percent of gas-fired storage heaters ("GSWHs"), 29 percent of oil-fired storage water heaters ("OSWHs"), and 9 percent of electric storage water heaters ("ESWHs") will be shipped to commercial applications in 2030.
[46] BRG Building Solutions, The North American Heating & Cooling Product Markets (2023 Edition). Available at *www.brgbuildingsolutions.com/reports-insights* (last accessed December 1, 2023).
[47] Clear Seas Research, 2022 Mechanical System - Water Heater. Available at *clearseasresearch.com/reports/industries/mechanical-systems/* (last accessed December 1, 2023).
[48] Based on available data, DOE assumed that the consumer water heater goes through the: wholesaler/contractor 50 percent of the time for GSWHs, 90 percent of the time for OSWHs, and 45 percent of the time for ESWHs; directly form the retailer 45 percent of the time for GSWHs, 5 percent of the time for OSWHs, and 50 percent of the time for ESWHs, and retailer/contractor 5 percent of the time for GSWHs, OSWHs, and ESWHs.

For mobile home replacement or new owner applications, there is one additional distribution channel where manufacturers sell to mobile home dealers/retail outlets that then sell to the customer.[49]

Mainly for consumer water heaters in commercial applications, DOE considers an additional distribution channel for which the manufacturer sells the equipment to the wholesaler and then to the consumer through a national account in both replacement and new construction markets.

The new construction distribution channel includes an additional link in the chain—the builder. The distribution channels for consumer water heaters in new construction[50] in residential applications (not including mobile homes) are characterized as follows:[51]

Manufacturer ➔ Wholesaler ➔ Plumbing Contractor ➔ Builder ➔ Consumer

Manufacturer ➔ Wholesaler ➔ Builder ➔ Consumer

Manufacturer ➔ Wholesaler (National Account) ➔ Consumer

[49] Based on available data, DOE assumed that the consumer water heater in mobile homes goes through the: wholesaler/contractor 5 percent of the time for GSWHs, 90 percent of the time for OSWHs, and 5 percent of the time for ESWHs; directly form the retailer 10 percent of the time for GSWHs, 5 percent of the time for OSWHs, and 25 percent of the time for ESWHs; retailer/contractor 5 percent of the time for GSWHs, OSWHs, and ESWHs; and directly through mobile home retailer 80 percent of the time for GSWHs, 0 percent of the time for OSWHs, and 65 percent of the time for ESWHs.

[50] DOE estimates that in the residential market 10 percent of GSWHs, 2 percent of OSWHs, and 15 percent of ESWHs will be shipped to new construction applications in 2030.

[51] DOE believes that many builders are large enough to have a master plumber and not hire a separate contractor, and assigned about half of water heater shipments to new construction to this channel. DOE estimated that in the new construction market, 90 percent of the residential (not including mobile homes) and 80 percent in commercial applications goes through a wholesalers to builders channel and the rest go through national account distribution channel.

For new construction, all mobile home GSWHs and ESWHs are sold as part of mobile homes in a specific distribution chain characterized as follows:

Manufacturer ➔ Mobile Home Manufacturer ➔ Mobile Home Dealer ➔ Consumer

DOE developed baseline and incremental markups for each actor in the distribution chain. Baseline markups are applied to the price of products with baseline efficiency, while incremental markups are applied to the difference in price between baseline and higher-efficiency models (the incremental cost increase). The incremental markup is typically less than the baseline markup and is designed to maintain similar per-unit operating profit before and after new or amended standards.[52]

To estimate average baseline and incremental markups, DOE relied on several sources, including: (1) form 10-K[53] from U.S. Securities and Exchange Commission ("SEC") for Home Depot, Lowe's, Wal-Mart, and Costco (for retailers); (2) U.S. Census Bureau 2017 Annual Retail Trade Report for miscellaneous store retailers (NAICS 453) (for online retailers)[54]; (3) U.S. Census Bureau 2017 Economic Census data[55] on the residential and commercial building construction industry (for builder, plumbing

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[52] Because the projected price of standards-compliant products is typically higher than the price of baseline products, using the same markup for the incremental cost and the baseline cost would result in higher per-unit operating profit. While such an outcome is possible, DOE maintains that in markets that are reasonably competitive it is unlikely that standards would lead to a sustainable increase in profitability in the long run.
[53] U.S. Securities and Exchange Commission. Company Filings. Available at*www.sec.gov/edgar/searchedgar/companysearch.html* (last accessed December 1, 2023).
[54] U.S. Census Bureau, *2017 Annual Retail Trade Report*, available at *www.census.gov/programs-surveys/arts.html* (last accessed December 1, 2023). Note that the 2017 Annual Retail Trade Report is the latest version of the report that includes detailed operating expenses data.
[55] U.S. Census Bureau, *2017 Economic Census Data*. available at *www.census.gov/programs-surveys/economic-census.html* (last accessed December 1, 2023). Note that the 2017 Economic Census Data is the latest version of this data.

contractor, mobile home manufacturer, mobile home retailer/dealer); and (4) the U.S. Census Bureau 2017 Annual Wholesale Trade Report data [56] (for wholesalers). DOE assumes that the markups for national accounts is half of the value of wholesaler markups. In addition, DOE used the 2005 Air Conditioning Contractors of America's ("ACCA") Financial Analysis on the Heating, Ventilation, Air-Conditioning, and Refrigeration ("HVACR") contracting industry[57] to disaggregate the mechanical contractor markups into replacement and new construction markets for consumer water heaters used in commercial applications.

PHCC commented that DOE's approach of incremental markups is not representative of how contractors set markups. PHCC commented that contractors know the required profit margin and set markups accordingly, rather than determining a markup for a baseline product and deciding a lower appropriate markup based on additional costs due to increased standards. (PHCC, No. 1151 at pp. 5-6) Rheem agreed that DOE's estimates of manufacturers' production costs for electric resistance and heat pump water heaters appear reasonable and that the retail price for electric resistance water heaters is accurate but the retail price of heat pump water heaters is a little low. Rheem recommended reviewing incremental markups for heat pump water heaters. Rheem also

[56] U.S. Census Bureau, *2017 Annual Wholesale Trade Report*. available at *www.census.gov/wholesale/index.html* (last accessed December 1, 2023). Note that the 2017 AWTR Census Data is the latest version of this data.

[57] Air Conditioning Contractors of America ("ACCA"), *Financial Analysis for the HVACR Contracting Industry* (2005), available at *www.acca.org/store#/storefront* (last accessed December 1, 2023). Note that the 2005 Financial Analysis for the HVACR Contracting Industry is the latest version of the report and is only used to disaggregate the mechanical contractor markups into replacement and new construction markets.

requested clarification on whether incremental markups are current markups or estimated for the compliance date of the rulemaking. (Rheem, No. 1177 at pp. 8-9)

In response, the development of all markup values is based on the most current data available, representing current markups applied to the products. The markups analysis is intended to represent products sold and installed at higher volume, since such products become the new baseline efficiency in the standards cases. Comparisons to current retail prices are therefore not necessarily applicable if such products are not common, high-volume products. For example, heat pump water heaters currently have a small market share and have higher profit margins. In a standards case with heat pump water heaters as the new baseline efficiency, their markups will be more representative of high-volume products. DOE also acknowledges that the contractor and customer relationship is of value and hence assigns contractors as an active market participant for a major portion of its distribution channels. For contractor markups, DOE utilized the 2017 Economic Census data, the latest data source consisting of the detailed operating costs needed to derive incremental markups. DOE believes that while contractors are unlikely to directly estimate an incremental markup in response to the cost change due to efficiency standards, contractor behavior is consistent with the characterization of DOE's markup approach which results in lower overall markup than baseline markup. DOE does not mean to suggest that contractors will directly adjust their markups on equipment if the price they pay goes up as a result of appliance standards. Rather, the approach assumes that such adjustment will occur over a (relatively short) period of time as part of a business management process. In summary, DOE acknowledges that its approach to estimating distributor and contractor markup practices after amended standards take effect is an approximation of real-world practices that are both complex and varying with business conditions. However, it continues to believe that its assumption that standards do not facilitate a sustainable increase in profitability is reasonable.

In addition to the markups, DOE obtained State and local taxes from data provided by the Sales Tax Clearinghouse.[58] These data represent weighted average taxes that include county and city rates. DOE derived shipment-weighted average tax values for each State considered in the analysis.

In response to the July 2023 NOPR, AHRI advised that DOE's process should include industry participation by surveying manufacturers, distributors, and consumers and DOE should conduct another round of confidential interviews with manufacturers and reevaluate based on those interviews. (AHRI, No. 1167 at p. 11)

In support of the July 2023 NOPR, DOE conducted confidential interviews with OEMs representing approximately 80 percent of domestic industry consumer water heater shipments. In those interviews, DOE requested information about a range of topics including distribution channels. *See* appendix 12-A of the final rule TSD for a copy of the manufacturer interview guide. DOE also conducted confidential interviews with consumer water heater OEMs in support of the March 2022 Preliminary Analysis. Data collected through this process was recent and sufficient to conduct the analysis given that market conditions have remained largely the same since those confidential

[58] Sales Tax Clearinghouse Inc., *State Sales Tax Rates Along with Combined Average City and County Rates* (June 14, 2023). Available at *www.thestc.com/STrates.stm*) (last accessed December 1, 2023).

interviews. Chapter 6 of the final rule TSD provides details on DOE's development of markups for consumer water heaters.

E. Energy Use Analysis

The purpose of the energy use analysis is to determine the annual energy consumption of consumer water heaters at different efficiencies in representative U.S. single-family homes, mobile homes, multi-family residences, and commercial buildings, and to assess the energy savings potential of increased consumer water heater efficiency. The energy use analysis estimates the range of energy use of consumer water heaters in the field (*i.e.*, as they are actually used by consumers). The energy use analysis provides the basis for other analyses DOE performed, particularly assessments of the energy savings and the savings in consumer operating costs that could result from adoption of amended or new standards.

DOE estimated the annual energy consumption of consumer water heaters at specific energy efficiency levels across a range of climate zones, building characteristics, and water heating applications. The annual energy consumption includes the natural gas, liquid petroleum gas ("LPG"), and electricity used by the consumer water heater.

1. Building Sample

To determine the field energy use of consumer water heaters used in homes, DOE established a sample of households using consumer water heaters from EIA's 2015 Residential Energy Consumption Survey ("RECS 2015") in the July 2023 NOPR, which was the most recent such survey that was then fully available.[59] The RECS data provide information on the vintage of the home, as well as water heating energy use in each household. DOE used the household samples not only to determine water heater annual energy consumption, but also as the basis for conducting the LCC and PBP analyses. DOE projected household weights and household characteristics in 2030, the first year of compliance with any amended or new energy conservation standards for consumer water heaters. To characterize future new homes, DOE used a subset of homes in RECS that were built after 2000.

In response to the July 2023 NOPR, Gas Association Commenters, Essency, Rinnai, and Atmos Energy commented that RECS 2015 should not have been used for the analysis and therefore the entire analysis is flawed. Gas Association Commenters stated that DOE had plenty of time to use RECS 2020 data and chose not to make their results look better. (Gas Association Commenters, No. 1181 at p. 32; Essency, No. 1194 at p. 3; Atmos Energy, No. 1183 at pp. 5-6; Rinnai, No. 1186 at p. 33) NYSERDA supported DOE's analysis, including RECS data and the consumer choice model analysis methodology. (NYSERDA, No. 1192 at pp. 3-4)

In response, DOE notes that RECS 2020 published finalized microdata in June 2023, with further updates published in July and September 2023. When conducting the analysis for the NOPR, the full set of microdata was not available. For this final rule, however, DOE incorporated RECS 2020 as the basis of the building sample development

[59] Energy Information Administration ("EIA"), 2015 Residential Energy Consumption Survey ("RECS"). Available at *www.eia.gov/consumption/residential/* (last accessed December 1, 2023).

and updated the analyses accordingly.[60] DOE agrees that incorporating RECS 2020 improves the representativeness of the residential building sample as RECS 2020 brings a threefold increase in sample size compared to RECS 2015.[61] A larger sample size generally results in smaller standard errors, especially for estimates of smaller subpopulations. In this final rule, DOE maintains a similar methodology in sample development for the analyzed product classes. The details of selection criteria and the resulting sample size for each product class are presented in the final rule TSD (*see* chapter 7 and appendix 7A).

To determine the field energy use of consumer water heaters used in commercial buildings, DOE established a sample of buildings using consumer water heaters from EIA's 2018 Commercial Building Energy Consumption Survey ("CBECS 2018"), which is the most recent such survey that is currently fully available.[62] DOE has maintained its sample development methodology used in July 2023 NOPR for consumer water heaters used in commercial applications.

2. Hot Water Use Determination

Calculating hot water use for each sample household requires assigning the water heater a specific tank size (referred to as rated volume). For each household, RECS reports the size bin of the water heater (30 gallons and less, 31 to 49 gallons, and 50

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[60] Energy Information Administration ("EIA"), 2020 Residential Energy Consumption Survey ("RECS"). Available at *www.eia.gov/consumption/residential/* (last accessed December 1, 2023).
[61] According to published data and EIA website, RECS 2020 is based upon responses collected from in total 18,496 households which is three times greater than 5,686 respondents in RECS 2015.
[62] U.S. Department of Energy: Energy Information Administration, Commercial Buildings Energy Consumption Survey (2018). Available at: *www.eia.gov/consumption/commercial/data/2018/index.php?view=microdata* (last accessed Dec. 1, 2023).

gallons and more); for each commercial building, DOE assumes that the water heater generally falls under the biggest size option applicable for each product class. For each size bin, DOE derived the fraction of models falling under each draw patterns and assigns the sampled water heater to an appropriate one (i.e., low, medium, and high). A specific tank size is then assigned based on the size bin and the draw pattern from the typical water heater sizes. Typical water heater sizes are the most common sizes for each product class and have the minimum energy factor allowed by current energy conservation standards. They are 30, 40, and 50 gallon for gas and electric storage water heaters, 30 and 50 gallon for oil, and 60 and 75 gallon for electric storage water heaters larger than 55 gallons. For the product class of ESWHs smaller than 35 gallons, DOE also assigned a fraction the tank size of 35 gallons. These sizes are referred to as "standard" sizes. Finally, DOE calculated the hot water use for each household and building based on the characteristics of the water heater and the reported water heating energy use.

In order to disaggregate the selected sampled water heaters into draw patterns and standard sizes, DOE used a variety of sources including RECS historical data on reported tank sizes, input from an expert consultant, and model data from DOE's public CCD[63] and AHRI certification directory[64] together with other publicly available data from manufacturers' catalogs of consumer water heaters. For all product classes, DOE used disaggregated shipments data by rated volume from BRG Building Solutions 2023 report

[63] U.S. Department of Energy's Compliance Certification Database is available at *regulations.doe.gov/certification-data* (last accessed December 1, 2023).
[64] Air Conditioning Heating and Refrigeration Institute. Consumer's Directory of Certified Efficiency Ratings for Heating and Water Heating Equipment. December 1, 2023. (Available at *www.ahridirectory.org*) (last accessed December 1, 2023).

from 2007 to 2022[65] and data from U.S. Census Bureau data (2003–2008).[66] Finally to determine the appropriate product type and size for different applications, DOE used manufacturer-produced consumer water heater sizing guidelines and calculators.

AHRI recommended DOE explain its inputs in the energy use calculations. AHRI commented that DOE's use of nesting of various assumptions for residential water heaters leads to unlikely results that DOE does not, or cannot, explain. (AHRI, No. 1167 at p. 19) AHRI also asked why DOE has not accepted the suggestion by AHRI and others to use median, not the mean values for consumption and LCC savings to avoid the effects of these outliers and to alleviate, at least in part, the deficiencies of its base case random assignment issue. (AHRI, No. 1167 at p. 20)

In response, DOE notes that RECS data provides the information on the household size and water heating energy use. RECS is the most comprehensive, nationally-representative, and robust data source on household energy consumption available to DOE. In general, DOE has found that the weighted average energy use for water heating correlates with the size of the household, *i.e.*, the reported number of people in that household. Greater energy expenditure on water heating largely falls into the bins of households of larger sizes (4 people and above). The hot water use derived based on the water heating energy use follows similar pattern (see chapter 7 of the final rule TSD for the calculation of hot water use). When reporting the distribution of the derived hot water use, DOE takes into account both consumer water heaters in residential

[65] BRG Building Solutions. The North American Heating & Cooling Product Markets (2023 Edition). 2023.
[66] U.S. Census Bureau. Current Industrial Reports for Major Household Appliances 2003-2008. Washington, D.C. Report No. MA335F.

as well as consumer water heaters used in commercial applications and close to 40 percent of the top 5 percent of water consuming sample buildings/households are commercial applications which generally have higher upper bound of hot water use. These outlier data points therefore represent either data directly reported from RECS for larger households or commercial applications using consumer water heaters, both of which represent real-world usage. In addition, DOE evaluates each sampled building/household individually by calculating its hot water use and the corresponding cost efficiency thereafter and that DOE believes the average LCC savings as reported is a good representation of the aggregated national values. Nevertheless, the LCC spreadsheet includes a calculation of median LCC savings, as well as LCC savings at various percentiles. Even if DOE were to rely on the median LCC savings instead of the mean LCC savings, DOE's conclusion of economic justification would remain the same.

Gas Association Commenters argued that water consumption should be based on household size and that there are problems with water consumption calculations. Gas Association Commenters argue the model results in unrealistic outliers for smaller households reaching consumption levels equivalent to space heating. Gas Association Commenters argue that a potential reason for this failure is how the model calculates daily water usage. For example, Gas Association Commenters argued that in DOE's model, some single person households use 200-350 gallons a day which is far from reasonable (4-7 baths of water a day every day of the year). Gas Association Commenters argued that Draw Pattern ID is based on randomly assigned distribution. Gas Association Commenters argue that for small storage units, there is a 5 percent chance of a large draw pattern Gas Association Commenters argues that a better solution would be to use the test procedure for water heaters as a basis for modeling energy usage rather than assuming draw rates based on the size of the original equipment in RECS. (Gas Association Commenters, No. 1181 at pp. 25-31) Rinnai argued that hot water usage should be determined through less opaque methods than the current method. Rinnai stated that rather than using RECS data to determine water usage, DOE should use test procedure defined hot water usage rates for comparisons of ELs. Rinnai stated that they believe that doing so would provide clearer consistency in comparison of residential water heater technologies generally and for EL comparison for proposed efficiency thresholds. Rinnai also stated that this would make DOE's analysis more consistent with other federal rating programs such as the FTC energy guide labeling program. (Rinnai, No. 1186 at p. 26 and p.33) Furthermore, Rinnai commented that if RECS is to be used, RECS 2015 is outdated and RECS 2020 should be used for this analysis. (Rinnai, No. 1186 at p. 33) On the contrary, NEEA supported DOE's overall method of analysis using Monte Carlo simulations informed by RECS data. NEEA commented that the Monte Carlo approach can successfully represent the true distribution of water product classes, hot water use, energy use and costs and that NEEA uses a similar approach when conducting similar analysis. NEEA commented that RECS serves as a reliable national dataset that helps account for the diversity found in the water heater market. (NEEA, No. 1199 at p. 5)

In response, for this final rule, DOE incorporated the latest RECS 2020 data for its analyses. With the increased sample size and the most recent timeline of the fielding of the survey, DOE believes that it provides a sample pool of more up to date national representation of housing characteristics and energy consumption of the home appliances.

As discussed previously, the weighted average of the energy use on water heating and the derived hot water use generally correlates with the size of the household with deviations that represent the real world complexities of the use of hot water heater in households of different types. DOE continues to rely on RECS as the basis of its analyses for its incomparable scope of coverage on housing characteristics and energy consumption and believes that it is an objective reflection of the landscape in the national water heater market. In terms of the assignment of draw pattern, DOE derived the distribution of different draw patterns based on market research of the number of models in each bin that are available on the market. The breakdown can be found in chapter 7 of the final rule TSD.

Ecotemp commented that the DOE consumer usage assumptions do not match the water use patterns of cabins, vacation homes, rental properties, or any other intermittent use dwelling. (Ecotemp, No. 1092 at p. 2) In response, RECS does not include in the survey house types like vacant, seasonal, vacation homes and group quarters and thus DOE build its analysis around regular households. However, in both residential households (sample by RECS) and commercial buildings (CBECS) DOE has observed samples with lower than usual water heating energy use. As stated previously, DOE believes that RECS and CBECS provide a nationally representative sample pool that includes a variety of housing types.

3. Energy Use Determination

To calculate the energy use of consumer water heaters, DOE determined the energy consumption associated with water heating and any auxiliary electrical use. In addition, for heat pump water heaters, DOE also accounted for the indirect effects of heat pump water heaters on heating, cooling, and dehumidification systems to compensate for the effects of the heat pump operation.[67] DOE calculated the energy use of water heaters using a simplified energy equation, the water heater analysis model ("WHAM"). WHAM accounts for a range of operating conditions and energy efficiency characteristics of water heaters. Water heater operating conditions are indicated by the daily hot water draw volume, inlet water temperature, thermostat setting, and air temperature around the water heater (ambient air temperature). To describe energy efficiency characteristics of water heaters, WHAM uses three parameters that also are used in the DOE test procedure: recovery efficiency ("*RE*"), standby heat-loss coefficient ("*UA*"), and rated input power ("P_{ON}").

The current version of WHAM is appropriate for calculating the energy use of electric resistance storage water heaters. To account for the characteristics of other types of water heaters, energy use must be calculated using modified versions of the WHAM equation. These modified versions are further discussed in chapter 7 and appendix 7B of the final rule TSD.

The daily hot water draw volume is estimated based on the water heater energy use estimated from RECS 2020 and CBECS 2018. The inlet water temperature is based on weather station temperature data and RECS 2020 ground water temperature data for each household. The consumer water heater thermostat setting is based on multiple

[67] If the heat pump water heater is installed in a conditioned space and is un-ducted, the cooling byproduct of the heat pump operation could produce a cooling effect that could increase space heating energy use in the heating season and decrease space cooling energy use in the cooling season. In addition, heat pump operation could also produce a dehumidifying effect that could reduce dehumidifier equipment energy use.

sources including contractor survey data and field data. To estimate the air temperature around the water heater (ambient air temperature), DOE assigned the sampled water heaters a water heater installation location including indoors (in the living space, such as an indoor closet), basement, garages, crawlspaces, outdoor closets, attics, etc. These fractions vary significantly by region and type of home, and match available survey data. Once the water heater is assigned an installation location, DOE then uses a methodology to determine the surrounding water heater ambient temperature. For example, in indoor locations the temperatures are assumed to be equal to the thermostat temperature. Other locations such as unconditioned attics or unconditioned basements/crawlspaces, outdoor closets, garages could have temperatures that are either lower than 32 deg. or above 100 deg. for a fraction of the year. *See* chapter 7 and appendix 8D (installation costs) of the final rule TSD for more details about the installation location methodology and ambient temperature methodology.

ONE Gas commented that DOE responded that it uses test procedure energy descriptor performance to determine energy use that is then "convert[ed]…to field energy use using modified WHAM equations," but ONE Gas's review of these procedures as found in appendix 7B of the Preliminary Analysis TSD suggests that the energy consumption estimates modeled do not meet the intent of the NASEM peer review, and DOE's response is effectively incomplete. ONE Gas recommended that DOE (1) use the test procedure assumptions of hot water consumption (based on the UEF draw patterns for residential water heating products) as the basis for comparing efficiency levels and alternatives for minimum efficiency standards, and (2) use WHAM calculations or other methods for scaling up efficiency level savings for the forecasted market under the ELs analyzed. (ONE Gas, No. 1200 at p. 9) In response, the appendix 7B in Preliminary Analysis TSD was merged in chapter 7 in NOPR TSD. Cross-reference pointing to appendix 7B for the energy use methodology in the TSD in the July 2023 NOPR was a typo DOE now has corrected. Description of the use of WHAM can be found in chapter 7 of the final rule TSD. As discussed in section IV.E.2 of this document, DOE determines that calculating the hot water use based on RECS reports presents a representative distribution of real world energy consumption and the use of WHAM equation is essential for translating energy consumption into hot water use. DOE maintains its methodology in this final rule to use RECS-reported water heating energy use and WHAM equation to calculate the corresponding energy use for each efficiency level of each product classed for sampled households/buildings.

For heat pump water heaters, energy efficiency and consumption are dependent on ambient temperature. To account for this factor, DOE expanded the WHAM to include a heat pump performance adjustment factor. The equation for determining the energy consumption of heat pump water heaters is similar to the WHAM equation, but a performance adjustment factor that is a function of the average ambient temperature is applied to adjust RE. In response to the July 2023 NOPR, Essency noted that the energy consumption model used in the analysis utilizes a recovery efficiency model that is too simplified and overestimated. They stated that the recovery efficiency model is a quadratic function with a minimum temperature of roughly 45 °F–50 °F which gives it a recovery efficiency at 37 °F, which Essency commented is a temperature where most of the current heat pump water heaters are working with electric resistance only. Essency also commented that the energy removed from the air is deducted in warmer months but this energy is not considered for cold months where the energy is removed from a heated space, which Essency asserted creates a bias in the published efficiency of heat pump water heaters. Essency also commented that the surrounding air temperature was used to calculate the efficiency of the heat pump even in the ducted configuration. (Essency, No. 1194 at p. 2) Armada argued that the energy savings are only realized under specific space and climate conditions, and deviations from these ideal conditions diminish the efficiency of a heat pump water heater. Armada noted that many heat pump water heaters have back up electric resistance heating, and when these space and climate conditions are not met, the water heater will utilize resistance heating – all of the cost of a heat pump with none of the anticipated benefits. (Armada, No. 1193 at pp. 5-6) NRECA commented that stakeholders in cold climates are concerned about the effectiveness of heat pump water heaters during extreme cold events. In cold climates, and particularly during extreme cold events, heat pump water heater in garages or other unconditioned spaces would operate electric resistive heating elements for a large portion of the day, resulting in high energy use and reducing LCC savings. NRECA commented that cooperatives such as Agralite Electric Cooperative in Minnesota and Iowa Lakes Electric Cooperative in Iowa expressed concerns related to the energy the heat pump water heater removes from the home if installed in the conditioned space. Because the heat pump water heater draws its energy from the air in the home, the space heating system must resupply heat taken up by the heat pump water heater. (NRECA, No. 1127 at p. 12)

In response, DOE notes that the analyses account for the energy consumption when the heat pump water heater is operating on electric resistance mode. DOE estimated that the electric resistance mode of operation is used 100 percent of the time when the monthly ambient temperature is less than 32 ºF or more than 100 ºF. As Essency noted, DOE adjusts the recovery efficiency in a quadratic function to account for the changes in performance of the heat pump under different conditions. DOE slightly updated the adjustment function for this final rule so that when below 32 ºF and above 100 ºF the electric resistance mode is considered. DOE also modified the methodology to take into account the outdoor temperature in ducted setting per Essency's comment. A heat pump water heater also operates in the electric resistance mode for part of the time even when the monthly ambient temperature (where the equipment is installed) is between 32 ºF and 100 ºF because this product has a slower recovery rate than an electric resistance water heater. DOE determined that, depending on household hot water consumption patterns, the electric resistance mode of operation varies significantly from household to household; on average DOE estimated that electric resistance mode accounts for 10 percent of the heat pump water heater unit's operating time. Lastly, because of the cooling effect heat pump water heater can have during heating season, DOE also estimated that two-thirds of heat extracted from the air by the heat pump water heater is replaced by the space conditioning system, which was taken in account for the heating season.

Gas Association Commenters commented that there is a bug in the LCC tool that causes it to use only a single year of weather data rather than 10-year average. (Gas Association Commenters, No. 1181 at p. 34) In response, DOE notes that the analysis uses the NOAA's 30 year average weather data for the outside air temperature for all product classes.

Chapter 7 of the final rule TSD provides details on DOE's energy use analysis for consumer water heaters.

F. Life-Cycle Cost and Payback Period Analysis

DOE conducted LCC and PBP analyses to evaluate the economic impacts on individual consumers of potential energy conservation standards for consumer water heaters. The effect of new or amended energy conservation standards on individual consumers usually involves a reduction in operating cost and an increase in purchase cost. DOE used the following two metrics to measure consumer impacts:

- The LCC is the total consumer expense of an appliance or product over the life of that product, consisting of total installed cost (manufacturer selling price, distribution chain markups, sales tax, and installation costs) plus operating costs (expenses for energy use, maintenance, and repair). To compute the operating costs, DOE discounts future operating costs to the time of purchase and sums them over the lifetime of the product.

- The PBP is the estimated amount of time (in years) it takes consumers to recover the increased purchase cost (including installation) of a more-efficient product through lower operating costs. DOE calculates the PBP by dividing the change in purchase cost at higher efficiency levels by the change in annual operating cost for the year that amended or new standards are assumed to take effect.

For any given efficiency level, DOE measures the change in LCC relative to the LCC in the no-new-standards case, which reflects the estimated efficiency distribution of consumer water heaters in the absence of new or amended energy conservation standards. In contrast, the PBP for a given efficiency level is measured relative to the baseline product.

For each considered efficiency level in each product class, DOE calculated the LCC and PBP for a nationally representative set of housing units and commercial buildings. As stated previously, DOE developed household samples from the RECS 2020 and CBECS 2018. For each sample household and commercial building, DOE determined the energy consumption for the consumer water heaters and the appropriate energy price. By developing a representative sample of households and commercial buildings, the analysis captured the variability in energy consumption and energy prices associated with the use of consumer water heaters.

Inputs to the calculation of total installed cost include the cost of the product—which includes MPCs, manufacturer markups, retailer and distributor markups, shipping costs, and sales taxes—and installation costs. Inputs to the calculation of operating expenses include annual energy consumption, energy prices and price projections, repair and maintenance costs, product lifetimes, and discount rates. DOE created distributions of values for product lifetime, discount rates, and sales taxes, with probabilities attached to each value, to account for their uncertainty and variability.

The computer model DOE uses to calculate the LCC relies on a Monte Carlo simulation to incorporate uncertainty and variability into the analysis. The Monte Carlo simulations randomly sample input values from the probability distributions and consumer water heater user samples. For this rulemaking, the Monte Carlo approach is implemented in MS Excel together with the Crystal Ball™ add-on.[68] The model calculated the LCC for products at each efficiency level for 10,000 water heater installations in housing and commercial building units per simulation run. The analytical results include a distribution of 10,000 data points showing the range of LCC savings for a given efficiency level relative to the no-new-standards case efficiency distribution (as shown in chapter 8 of the final rule TSD). In performing an iteration of the Monte Carlo simulation for a given consumer, product efficiency is chosen based on its probability. At the high end of the range, if the chosen product efficiency is greater than or equal to the efficiency of the standard level under consideration, the LCC calculation reveals that the hypothetical consumer represented by that data point is not impacted by the standard level because that consumer is already purchasing a more-efficient product. At the low end of the range, if the chosen product efficiency is less than the efficiency of the standard level under consideration, the LCC calculation reveals that the hypothetical consumer represented by that data point is impacted by the standard level. By accounting for consumers who already purchase more-efficient products, DOE avoids overstating the potential benefits from increasing product efficiency.

DOE calculated the LCC and PBP for consumers of consumer water heaters as if each were to purchase a new product in the first year of required compliance with new or

[68] Crystal Ball™ is commercially-available software tool to facilitate the creation of these types of models by generating probability distributions and summarizing results within Excel, available at *www.oracle.com/technetwork/middleware/crystalball/overview/index.html* (last accessed December 1, 2023).

amended standards. New and amended standards apply to consumer water heaters manufactured 5 years after the date on which any new or amended standard is published. (42 U.S.C. 6295(m)(4)(A)(ii)) Therefore, DOE used 2030 as the first full year of compliance with any amended standards for consumer water heaters.

Table IV.25 summarizes the approach and data DOE used to derive inputs to the LCC and PBP calculations. The subsections that follow provide further discussion. Details of the spreadsheet model, and of all the inputs to the LCC and PBP analyses, are contained in chapter 8 of the final rule TSD and its appendices.

Table IV.25 Summary of Inputs and Methods for the LCC and PBP Analysis*

Inputs	Source/Method
Product Cost	Derived by multiplying MPCs by manufacturer and retailer markups and sales tax, as appropriate. Used historical data to derive a price scaling index to project product costs.
Installation Costs	Baseline installation cost determined with data from RSMeans. Assumed no change with efficiency level.
Annual Energy Use	The total annual energy use multiplied by the hours per year. Average number of hours based on field data. Variability: Based on the RECS 2020 and CBECS 2018.
Energy Prices	Natural Gas: Based on EIA's Natural Gas Navigator data for 2022. Electricity: Based on EIA's Form 861 data for 2022. Propane and Fuel Oil: Based on EIA's State Energy Data System ("SEDS") for 2021. Variability: Regional energy prices determined for 50 states and District of Columbia for residential and commercial applications. Marginal prices used for natural gas, propane, and electricity prices.
Energy Price Trends	Based on *AEO2023* price projections.
Repair and Maintenance Costs	Based on RSMeans data and other sources. Assumed variation in cost by efficiency.
Product Lifetime	Based on shipments data, multi-year RECS, American Housing Survey, American Home Comfort Survey data.
Discount Rates	Residential: approach involves identifying all possible debt or asset classes that might be used to purchase the considered appliances, or might be affected indirectly. Primary data source was the Federal Reserve Board's Survey of Consumer Finances. Commercial: Calculated as the weighted average cost of capital. Primary data source was Damodaran Online.
Compliance Date	2030

* Not used for PBP calculation. References for the data sources mentioned in this table are provided in the sections following the table or in chapter 8 of the final rule TSD.

1. Product Cost

To calculate consumer product costs, DOE multiplied the MSPs developed in the engineering analysis by the markups described previously (along with sales taxes). DOE used different markups for baseline products and higher-efficiency products, because DOE applies an incremental markup to the increase in MSP associated with higher-efficiency products.

Examination of historical price data for certain appliances and equipment that have been subject to energy conservation standards indicates that the assumption of constant real prices may, in many cases, overestimate long-term trends in appliance and equipment prices. Economic literature and historical data suggest that the real costs of these products may in fact trend downward over time according to "learning" or "experience" curves.[69]

In the experience curve method, the real cost of production is related to the cumulative production or "experience" with a manufactured product. This experience is usually measured in terms of cumulative production. As experience (production) accumulates, the cost of producing the next unit decreases. The percentage reduction in cost that occurs with each doubling of cumulative production is known as the learning rate. In typical experience curve formulations, the learning rate parameter is derived using two historical data series: cumulative production and price (or cost). DOE obtained historical PPI data for water heating equipment from 1950-1961, 1968-1973, and 1977-

[69] Desroches, L.-B., K. Garbesi, C. Kantner, R. Van Buskirk, and H.-C. Yang. Incorporating Experience Curves in Appliance Standards Analysis. *Energy Policy*. 2013. 52 pp. 402–416; Weiss, M., M. Junginger, M. K. Patel, and K. Blok. A Review of Experience Curve Analyses for Energy Demand Technologies. *Technological Forecasting and Social Change*. 2010. 77(3): pp. 411–428.

2022 for electric consumer water heaters and from 1967-1973 and 1977-2022 for all other consumer water heaters from the U.S. Bureau of Labor Statistics' ("BLS").[70] The PPI data reflect nominal prices, adjusted for product quality changes. An inflation-adjusted (deflated) price index for heating equipment manufacturing was calculated by dividing the PPI series by the implicit price deflator for Gross Domestic Product Chained Price Index.

From 1950 to 2006, the deflated price index for consumer water heaters was mostly decreasing, or staying flat. Since then, the index has risen, primarily due to rising prices of copper, aluminum, and steel products which are the major raw material used in water heating equipment. The rising prices for copper and steel products were attributed to a series of global events, from strong demand from China and other emerging economies to the recent severe delay in commodity shipping due to the COVID-19 pandemic. Given the slowdown in global economic activity in recent years and the lingering impact from the global pandemic, DOE believes that the extent to which the trends of the past five years will continue is very uncertain. DOE also assumes that any current supply chain constraints are short-lived and will not persist to the first year of compliance. Given the uncertainty regarding the magnitude and direction of potential future price trends, DOE decided to use constant prices as the default price assumption to project future consumer water heater prices. Thus, projected prices for the LCC and PBP analysis are equal to the 2022 values for each efficiency level in each product class. However, DOE performed a sensitivity analysis utilizing both a decreasing and an increasing price trend (see appendix 8C). The relative comparison of potential standard

[70] Series ID PCU33522033522081 and PCU33522833522083; see *www.bls.gov/ppi/*.

levels remains the same regardless of which price trend is utilized and the conclusions of the analysis do not change.

BWC requested that DOE detail its methods in utilizing price learning curves for both heat pump water heater and condensing gas products, as was indicated in Section IV(F)(1) of the July 2023 NOPR, so that stakeholders may review them. BWC suggested the additional components required to manufacture higher efficiency products required by this proposal, in addition to their more complex manufacturing processes, will continue to compel higher product costs than is currently expected of non-condensing gas and electric resistance water heaters common in the market today, economies of scale notwithstanding. (BWC No. 1164 at p. 17) The available data only allow estimation of price trends for water heaters as a group, not for different efficiency levels of water heaters. DOE agrees that the product costs of heat pump water heater and condensing gas products will continue to be higher than non-condensing gas and electric resistance water heaters. However, it is reasonable to expect that factors affecting water heaters as a whole, such as growing experience in production or changes in commodity prices, will affect all water heaters. Thus, for this final rule, it used the same price trend projection for all water heaters.

2. Installation Cost

The installation cost is the cost to the consumer of installing the consumer water heater, in addition to the cost of the water heater itself. The cost of installation covers all labor, overhead, and material costs associated with the replacement of an existing water heater or the installation of a water heater in a new home, as well as delivery of the new water heater, removal of the existing water heater, and any applicable permit fees. Higher-efficiency water heaters may require consumers to incur additional installation costs.

DOE's analysis of installation costs estimated specific installation costs for each sample household based on building characteristics given in RECS 2020 and CBECS 2018. For this final rule, DOE used 2023 RSMeans data for the installation cost estimates, including labor costs.[71,72,73,74] DOE's analysis of installation costs accounted for regional differences in labor costs by aggregating city-level labor rates from RSMeans into 50 U.S. States and the District of Columbia to match RECS 2020 data and CBECS 2018 data.

PHCC stated that the costs calculated for the installation costs are too low. PHCC commented that the data source RSMeans is intended for larger contractor businesses and the data has not been properly adjusted for small businesses. PHCC noted a discrepancy in the water heater installation time between their RSMeans source and DOE's report. (PHCC, No. 1151 at p. 4) PHCC stated that the values listed in the overhead category for costs are not correct and questioned the 10% profit, believing it to be understated. PHCC commented that the overhead category will include office utilities and rent, support staff, supervisors, estimators, advertising, truck and tool acquisition expenses, fuel and

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[71] RSMeans Company Inc., *RSMeans Mechanical Cost Data*. Kingston, MA (2023) (Available at: *www.rsmeans.com/products/books/2022-cost-data-books*) (Last accessed December 1, 2023).
[72] RSMeans Company Inc., *RSMeans Residential Repair & Remodeling Cost Data. Kingston*, MA (2023) (Available at: *www.rsmeans.com/products/books/2022-cost-data-books*) (Last accessed December 1, 2023).
[73] RSMeans Company Inc., *RSMeans Plumbing Cost Data*. Kingston, MA (2023) (Available at: *www.rsmeans.com/products/books/2022-cost-data-books*) (Last accessed December 1, 2023).
[74] RSMeans Company Inc., *RSMeans Electrical Cost Data*. Kingston, MA (2023) (Available at: *www.rsmeans.com/products/books/2022-cost-data-books*) (Last accessed December 1, 2023).

maintenance, technician non-productive time and depreciation. PHCC estimated that vehicle and tooling can be 15% to 20% of a technician's hourly rate. PHCC commented that DOE's assumption of $27 per hour overhead for 1 residential plumber is too low. (PHCC, No. 1151 at p. 5) In response, RSMeans is a reputable source for cost estimation and it provides the national average labor rate for different crew types as well as regional rates, regardless of business size. DOE acknowledges that some individual contractors may depart from cost estimates determined by RSMeans, however RSMeans remains the most comprehensive and nationally representative data source for contractor rates and costs. The RSMeans database includes tens of thousands of individual line items and cost engineers spend tens of thousands of hours validating these costs every year. Thousands of contractors rely on RSMeans to determine cost estimates.[75] DOE adjust the labor rates for different regions based on where the sample household or building is located. In regards to PHCC's concern over the labor rate and overhead, DOE notes that the $27 per hour overhead for a residential plumber is pointing to 63% markup compared to the bare hourly rate. Taking into account regional difference, the exact dollar value of the markup increases for regions with labor rates higher than national average. For this final rule, DOE maintained the method of calculating labor rates as used in the July 2023 NOPR.

a. Basic Installation Costs and Inputs

First, DOE estimated basic installation costs that are applicable to all consumer water heaters, in replacement, new owner, and new home or building installations. These

[75] See: *www.rsmeans.com/info/contact/about-us* (Last accessed March 6, 2024).

costs include putting in place and setting up the consumer water heater, gas piping and/or electrical hookup, permits, water piping, removal of the existing consumer water heater, and removal or disposal fees.

NMHC and NAA commented that in existing or future commercial-to-residential conversions, by the nature of the building construction, historic building considerations or zero lot lines result in building facades that are frequently not available for vent terminations. They claimed that these buildings may be taller than a new residential building and existing structural frame geometries and shaft locations significantly influence dwelling unit configurations, in which cases new vent piping or condensate drains may need to traverse space outside of the affected dwelling unit to reach a building shaft with sufficient space to add piping. NMHC and NAA claimed that such piping runs will virtually always exceed the lengths cited for cost-analysis in the TSD and entail substantial additional costs unconsidered by DOE. (NMHC and NAA, No. 996 at p. 4) Gas Association Commenters argued that the installation cost did not address the breadth of existing multifamily configurations like high-rise, low-rise buildings, historic structures and adaptive reuse projects (*i.e.*, commercial to residential conversions). (Gas Association Commenters, No. 1181 at p. 4) In response, DOE notes that current shipments of consumer water heaters to commercial buildings are small, approximately 5 percent of total shipments (see chapter 9 of final rule TSD). These are typically small offices, restaurants, or smaller retailers with similar hot water demand to residential households, otherwise they would be utilizing commercial water heating equipment outside the scope of this final rule. Any existing commercial-to-residential building conversions would be present in the CBECS 2018. Any future commercial-to-residential conversions are speculative at this time. Even if vent piping for gas-fired water heaters were prohibitive for a given building, electric water heaters are available to supply hot water at lower cost to each individual unit, so there is no reason to expect substantially higher costs for these residential units. Their impacts would be very similar to those estimated for medium ESWH in new construction and/or multi-family buildings and thus captured by the analysis. Furthermore, if the existing commercial building utilizes a central commercial boiler to supply hot water, DOE expects that such building conversions will take advantage of the existing central commercial boiler system to supply hot water to the newly built residential units. Also, in order to satisfy the building codes, these conversions typically require very extensive reconstructions including building new central shafts that accommodate all of the piping and vents related to plumbing, HVAC and water heating needs. These shafts could serve the condensation withdrawal as required for the heat pump water heaters or condensing gas water heaters. In regards to the length of the piping runs, DOE's analysis includes a distribution of a wide range of piping length which covers the additional piping requirements. Regarding existing multi-family buildings, DOE clarifies that the analysis does include costs separately for multi-family buildings of various sizes (see appendix 8D), and the RECS sample includes such multi-family buildings, therefore they are captured in the LCC analysis. The majority of multi-family buildings utilize electric storage water heaters.

b. Gas-fired and Oil-fired Storage Water Heater Installation Costs

For gas-fired and oil-fired water heater installations, DOE included a number of additional costs ("adders") for a fraction of the sample households. Most of these additional cost adders are associated with installing higher efficiency consumer water heater designs in replacement installations.

For replacement installations, DOE conducted a detailed analysis of installation costs when a baseline (or minimum efficiency) consumer water heater is replaced with higher efficiency design options, with particular attention to space constraint issues (associated with larger dimensions for certain higher efficiency consumer water heaters), venting issues, and condensate withdrawal (for power vented and condensing gas-fired water heaters). Due to the larger dimensions of higher efficiency storage water heaters, installation adders included removing and replacing door jambs (to be able to fit the larger sized water heater). DOE also takes into account that a fraction of installations would include adding tempering valves for water heaters with increased set-point temperatures due to the household preference. For non-condensing gas-fired and oil-fired water heaters, additional costs included updating flue vent connectors, vent resizing, and chimney relining. For non-condensing power vented and condensing gas-fired storage water heaters, additional costs included adding a new flue vent, combustion air intake for direct vent installations, concealing vent pipes for indoor installations, addressing an orphaned furnace (by updating flue vent connectors, vent resizing, or chimney relining), and condensate removal. Freeze protection is accounted for in the cost of condensate removal for a fraction of condensing gas-fired water heaters installed in non-conditioned spaces.

DOE also included installation adders for new owner and new construction installations. For non-condensing gas-fired and oil-fired storage water heaters, a new flue vent and accounting for other commonly vented heating appliances are the only adders.

For power vented and condensing gas-fired water heaters, the adders include new flue vent, combustion air vent for direct vent installations, and condensate removal.

ONE Gas commented that venting costs are systematically under-estimated but did not provide more data. ONE Gas argued that the Department does not provide illustrations of the full range of site conditions covered or confirmation data for its distributional data. (ONE Gas, No. 1200 at p. 10) ONE Gas argued that the Department uses a simplistic presumption of single-family household replacement installation requirements (e.g., venting into masonry chimneys, common venting with furnace) for multifamily households whose water heater vents atmospherically into a common vent shared with other households, which neglects various concerns. (ONE Gas, No. 1200 at p. 10) PHCC requested clarification on the language on page 8D-7 of the NOPR TSD surrounding masonry chimneys. PHCC commented that the language gets confusing as it discusses lined masonry chimneys but then considers metal lining systems. PHCC noted that masonry chimneys must be tile lined for gas venting and it is unclear if DOE views the use of a flexible metal liner kit as a lined chimney. Furthermore, PHCC indicated the need for more clarification on the use of flexible liners in chases, as those chases should contain metallic double wall vents. Finally, PHCC requested clarification on the discussion surrounding isolated water heaters that are not gas-fired nor vented products, as PHCC is not clear on why they are called isolated and what their relationship is with common venting. (PHCC, No. 1151 at p. 3)

In response, DOE notes that sources and references used in the analysis for deriving the methodology are presented in chapter 8 of the TSD and its appendices. DOE is aware that in some multifamily buildings, existing non-condensing storage water heaters of more than one unit can be commonly vented with other equipment vented using a Category I vent. In some cases, replacement of one water heater may require re-assessment of the shared vent path. However, this final rule does not require a condensing level for gas storage water heaters. DOE notes that it is challenging to acquire data on how frequently water heaters are commonly vented in multifamily buildings that allow DOE to statistically account for the cost impact on its own. DOE estimates, however, certain fractions by region where chimney venting is applied and believes that, besides those typical cases where chimney venting is shared by a water heater and a furnace, those installation cases have captured to some extent the costs applicable for vent path reassessment. In regards to the PHCC's comment on appendix 8D of NOPR TSD, to clarify, DOE accounts for different types of venting used in the field; venting through a masonry chimney and venting through a metal vent going through the roof are both included. For venting in the masonry chimney, DOE takes into account the cost for relining the chimney and venting for orphaned furnace/boiler where applicable in retrofits. Specifically, when venting through the chimney, DOE accounts for the cost of chimney re-lining and resizing of the vent connector should the retrofit require that. Additionally, "isolated" water heaters as explained in the documentation refer to water heaters that are not commonly vented or do not require venting at all, for which there are no common venting related costs considered. See chapter 8 and appendix 8D of the final rule TSD for details.

CHPK stated that the modification associated with increasing insulation, the addition of a thermal flue damper, or an electronic ignition and an electronic flue damper would require an electric supply to gas-fired storage water heaters, and would potentially reduce vent temperatures resulting in excessive condensation developing in the vent. According to CHPK, these modifications would result in additional costs of providing an electric outlet for gas storage water heaters in a replacement situation and perhaps venting issues. (CHPK, No. 1008 at p. 1) DOE took into account in the calculation of installation costs the issues CHPK raised and applied a cost adder for an electric outlet and condensate treatment for the efficiency levels that require those.

Regarding statements from some stakeholders that significant installation barriers are associated with gas condensing water heaters, the CA IOUs referred DOE to a report docketed in 2019 titled "Investigation of Installation Barriers and Costs for Condensing Gas Appliances." Key findings from this report indicate that these challenges impact less than 5 percent of condensing gas retrofit installations for residential and commercial applications, and that condensate management and chimney relining were minor concerns for installing gas condensing products. (CA IOUs, No. 1175 at p. 2) DOE agrees that installation challenges will impact only a subset of consumers, and even in those cases, DOE has included additional installation costs into the analysis.

c. Heat Pump Water Heater Installation Costs

For heat pump water heater installations, DOE included a number of adders for a fraction of the sample households. Most of these adders are associated with installing heat pump water heaters in replacement installations.

For replacement installations, DOE conducted a detailed analysis of installation costs when a baseline consumer water heater is replaced with higher efficiency designs, with particular attention to space constraint issues (associated with larger dimensions for heat pump water heaters compared to electric resistance water heaters), condensate withdrawal, and ductwork for heat pump water heaters installed in conditioned spaces. To address the larger dimensions of heat pump water heaters, installation adders included removing and replacing door jambs (to be able to fit the larger sized water heater) or relocating water heater. Freeze protection is accounted for in the cost of condensate removal for a fraction of heat pump water heaters installed in non-conditioned spaces. DOE also included condensate removal installation adders for new owner and new construction heat pump water heater installations. DOE also accounted for the airflow requirements as specified in manufacturer installation manuals in its installation cost model. The additional costs of adding louvered doors, venting, or relocating a water heater are included for a fraction of installations, mainly for heat pump water heaters installed in indoor locations. See appendix 8D of the final rule TSD for more details.

PHCC commented that DOE acknowledges that up to 40% of installations could face space constrained heat pump installations and the suggestion that DOE provides to use louvered doors may not be applicable to all installations and the use of ducted air installations should be accounted for. (PHCC, No. 1151 at p. 4) PHCC noted that on page 8D-6 of NOPR TSD there are no modifications to remove and replace door jambs for basements and garages, but plumbing, building and mechanical codes require doorways to be of sufficient size to replace equipment without future removal of doors and door frames. (PHCC, No. 1151 at p. 3) NMHC and NAA noted that DOE's suggestion that it may be possible to ignore manufacturers' specified volume of space for heat pump water heater installation based on "current research" is not acceptable as it conflicts with building code requirements to comply with manufacturer's instructions. NMHC and NAA also commented that DOE's suggestion for installation of heat pump water heaters by replacing utility closet doors with louvered doors is not viable as it ignores the impacts of increases in equipment noise in the smaller area of the typical apartment home. (NMHC and NAA, No. 996 at p. 4) Essency argued that the cost of moving the heat pump water heater was not calculated as there are significant additional electrical, plumbing, and other construction work that are required. (Essency, No. 1194 at p. 2) EEI commented that it is important to recognize that installing heat pump water heater units in space-constrained areas (like closets or under stairs or in crawl spaces) will require significant retrofit costs given heat pump water heaters' physical operating requirements and the potential need for additional equipment. EEI commented that non-ducted heat pump water heaters require at least 700 cu ft of space to operate properly and achieve DOE's estimated efficiency levels, as shown in manufacturer specifications. EEI noted that 10 to 40 percent of water heaters are located in closets based on a survey by Southern Company. EEI commented that DOE's analysis does not include a realistic cost estimate for replacing electric resistance water heaters with heat pump water heaters in closets where walls, ceilings, and doors must be removed and replaced or ductwork added in space constrained areas. EEI argued that DOE's analysis does not accurately account for the replacement costs in other space-constrained environments such as crawl spaces, attics, utility rooms, or laundry rooms (EEI, No. 1198 at pp. 5-6) Armada argued that ideal efficiency conditions for heat pump water heaters require 1000 cubic feet of air. Armada argued that many homes cannot support such space demands, and use of heat pump water heaters will increase home heating costs for many consumers, diminishing any savings. Armada argued that only in very rare circumstances would consumers be able to quickly replace an electric storage water heater in an emergency, as many homes will require construction to accommodate the space and environment requirements of a heat pump water heater such as installing louvered doors or building ductwork. (Armada, No. 1193 at p. 6)

In response to the preceding comments, DOE notes that the analysis takes into account the cost of moving the water heater to a different location or adding a louvered door for some installations. In the field, plumbers would guide the customers to select a way that works for them. In the analysis, DOE acknowledges the possible occurrence of those additional costs and on top of those DOE also applied a distribution of installation cost adders that ranges from $0 to $4,000 in total for the most challenging installations, averaging $2,000 (see appendix 8D).

NRECA commented that manufactured and small homes experience greater impact from both noise and cold air exhaust than larger homes that have more space to isolate the noise of the water heater and more air volume to buffer cold air exhaust. They commented that constrained spaces may not have enough room for mitigation measures such as supply and exhaust air ducting or noise dampening equipment. NRECA added that consumers will not welcome any increase in their electricity bills resulting from their heating system needing to work harder because of the heat pump water heater drawing on the warm air as its heat source. (NRECA, No. 1127 at p. 6). NRECA commented that manufactured and small homes will face unique installation challenges with heat pump water heaters. They noted that small and manufactured homes in NRECA member territories typically use 40- to 50-gallon lowboys, tall tanks, or tanks specifically designed for manufactured home closets, and that although DOE created a small electric storage water heater product class that covers some lowboy products this does not include tank sizes and form factors that electric cooperatives typically observe in space constrained spaces. NRECA cited the La Plata Electric Association ("LPEA") pilot study where 20 heat pump water heaters were installed in owner-occupied manufactured homes and due to the complexity of installation, concluded that a majority of manufactured homes are not good candidates for a heat pump water heater. NRECA stated that although heat pump water heaters can be installed in some constrained spaces, they are likely not the best option when they cause high installation costs, noise and cold air impacts, and potentially unsightly installations to make the heat pump water heater fit a space that was never designed to accommodate it, and there often is no other available space in a small home to relocate the water heater, and reducing tank size can cause negative user experience. (NRECA, No. 1127 at pp. 6-7) NRECA commented that because low-and-moderate income consumers disproportionately face complex installations, they are likely to disproportionately bear costs rather than savings as a result of the proposed rule and they received multiple examples from electric cooperatives illustrating that installation costs are far higher than DOE's estimates. (NRECA, No. 1127 at p. 8)

NEEA noted that its research shows that heat pump water heaters can be installed in a wide range of conditions and climates, including very cold climates, and continue to deliver significant energy savings. (NEEA, No. 1199 at pp. 3-4) NEEA commented that its research supports DOE's installation cost analysis. (NEEA, No. 1199 at p. 7). However, BWC highlighted that NEEA is a regional organization that operates its programs primarily in the Northwestern United States and only included those consumers who had already made the decision to take advantage of available heat pump water heater rebate programs. (BWC, No. 1164 at p. 20)

In response, DOE acknowledges that manufactured homes and small homes typically have greater challenges in installing a heat pump water heater. Installing a heat pump water heater in such homes may require additional installation costs, as described above, more so than an average single-family home. The LCC analysis accounts for the higher installation costs for such homes. However, in many cases, such homes can utilize a small electric storage water heater instead of a heat pump water heater, significantly reducing their total installed cost. In terms of the cooling effect of the heat pump module, DOE took that into account in its energy use analysis the additional heating it might need in compensation, as discussed in section IV.E.3. DOE acknowledges that for low income homeowners, higher installation costs would indeed need more years of energy savings to pay back or may even lead to net cost, and this is accounted for in the overall LCC results. For renters, since they won't bear the first cost, it will more likely be economically beneficial (as discussed in section IV.I.1 of this document).

In the July 2023 NOPR, DOE did extensive revisions to its installation cost model to include installations of low-boy water heaters. DOE estimated around 10 percent of the total 20 to 55 gallon electric storage water heater market to be low boy water heaters. DOE assessed that many of these installations would require significant installation costs in order to install a heat pump water heater. DOE notes that at the proposed standard, most models currently serving the small electric water heater market will remain available.

A.O. Smith argued that retrofit costs associated with space-constrained installs are under-represented, especially for the lowboy electric resistance water heater to heat pump water heater transition. A.O. Smith also argued that undersizing an electric storage water heater ("ESWH") and raising the temperature would not be possible in scenarios where a heat pump water heater would not fit in a confined space (which represents half of the modeled outcomes). A.O. Smith stated that while the difference in size for tall ESWH replacements is accounted for with a ~3 inch diameter increase, this same change is not accounted for in a substantial way for lowboys which present an even greater size constraint challenge. (A.O. Smith, No. 1182 at pp. 8-9) A.O. Smith pointed out that they could not find the referenced "review of studies" mentioned in Appendix 8D of the NOPR TSD which was supposed to include a literature review and a comparison of results of studies (related to lowboy costs) in response to previously submitted comments. (A.O. Smith, No. 1182 at p. 9) AHRI commented that DOE is not adequately considering the retrofit costs associated with space constrained retrofits. Specifically, DOE did not consider the added product and installation costs that would be faced by homeowners when replacing medium draw pattern lowboy or "short" electric resistance water heater with a heat pump water heater. AHRI noted that consumers would not have the option to install an over-heated tank in lieu of facing space constrained scenarios as electric resistance storage water heaters with the capability of being overheated will not be permitted under the proposed energy conservation standard. AHRI stated that replacement of a lowboy with a heat pump would require the use of a more expensive split heat pump and would have additional installation costs. (AHRI, No. 1167 at p. 7)

DOE is aware of the challenges of replacing a low boy water heater with a heat pump water heater, especially in confined space and in small homes or manufactured homes. As discussed above and in the July 2023 NOPR, DOE applied significant installation cost adders to those installations to encompass the additional labor hour and materials needed to install such water heaters.

A.O. Smith argued that DOE did not fully account for the increased product and installation costs associated with split-system heat pump water heater designs that would be used to replace lowboy installations. A.O. Smith recommended that DOE incorporate higher product and installation costs associated with split designs for 13.7 percent of shipments in the medium electric storage water heater product class. (A.O. Smith, No. 1182 at p. 9) For this final rule DOE conducted further research on installing a heat pump water heater in a split system configuration. Currently there are not many models available for split system configuration and thus there are limited installation examples. DOE maintained its main analytical approach while adding a local installation cost sensitivity analysis for installing a split system heat pump water heater. Specifically, DOE modeled the cost line items needed for the installation of a 44-gallon low boy tank with a split heat pump module, which is a commonly used lowboy tank size for medium ESWHs. Appendix 8D of the final rule TSD provides more details on this sensitivity analysis. In summary, DOE found that the installation costs of a split system heat pump water heater are not necessarily higher than an integrated heat pump in a constrained space. Since DOE already applies a significant adder to the installation of an integrated heat pump water heater in these households, the overall average LCC savings would be more positive for the adopted heat pump level had DOE included this split heat pump option for medium electric storage water heaters in the main analysis. Even though the retail price for a split system heat pump water heater may be higher than an integrated heat pump, the lower installation cost for a split system heat pump water heater compared to an integrated heat pump water heater in a confined space and in small homes or manufactured homes is likely to result in an overall lower total installed cost. Should the market include more split heat pump models in the future, the likely cost impacts will decrease for consumers with water heaters in a confined space and in small homes or manufactured homes.

A.O. Smith argued that DOE's analysis assumed that all water heaters in manufactured homes are 30 gal and therefore did not account for the costs of these units transitioning to heat pump levels. A.O. Smith also pointed out that DOE acknowledges that 40 gal are also common standards for manufactured homes. (A.O. Smith, No. 1182 at p. 10) In response, DOE notes that the statement A.O. Smith was referencing was in a consultant report, where 30 gallon was only an example made to represent the cost breakdown of water heaters typically used in mobile homes. In DOE's actual analysis, different standard sizes were considered (see section IV.E.2 for more information).

Rheem found the reported installation costs for heat pump water heater to be lower than expected, but the incremental installation costs between EL 0 and EL 3 aligned with their internal installation cost data. Rheem noted that as operation at high tank temperatures is expected to be representative of electric resistance water heater operation, the installation of a mixing valve should be included in DOE's analysis. (Rheem, No. 1177 at p. 9) DOE has found that for some applications mixing valves are currently being used in order to have higher hot water temperature for dishwashers or clothes washers, to provide more hot water capacity, and to reduce bacterial growth, while making sure the delivered water is within a safe range.[76] Some water heaters have internal mixing valves that are meant to increase available hot water. In some cases, mixing valves could be used to address the increased hot water needs when the number of people in the household increases without replacing the entire water heater. DOE's updated test procedure includes a method to test water heaters in the highest storage tank temperature mode, which would be more representative for these types of installations (this is discussed more in section V.D.1). DOE's analysis in this final rule accounts for a fraction of installations that utilize a mixing valve.

3. Annual Energy Consumption

For each sampled household and building, DOE determined the energy consumption for consumer water heaters at different efficiency levels using the approach described previously in section IV.E of this document.

Higher-efficiency water heaters reduce the operating costs for a consumer, which can lead to greater use of the water heater. A direct rebound effect occurs when a product that is made more efficient is used more intensively, such that the expected energy savings from the efficiency improvement may not fully materialize. At the same time, consumers benefit from increased utilization of products due to rebound. Although some households may increase their water heater use in response to increased efficiency, DOE does not include the rebound effect in the LCC analysis because the increased utilization

[76] See *www.geappliances.com/appliance/GE-Smart-50-Gallon-Electric-Water-Heater-with-Flexible-Capacity-GE50S10BMM*.

of the water heater provides value to the consumer. DOE does include rebound in the NIA for a conservative estimate of national energy savings and the corresponding impact to consumer NPV. See chapter 10 of the FR TSD for more details.

4. Energy Prices

Because marginal energy price more accurately captures the incremental savings associated with a change in energy use from higher efficiency, it provides a better representation of incremental change in consumer costs than average electricity prices. Therefore, DOE applied average energy prices for the energy use of the product purchased in the no-new-standards case, and marginal energy prices for the incremental change in energy use associated with the other efficiency levels considered.

DOE derived average monthly marginal residential and commercial electricity, natural gas, and LPG prices for each state using data from EIA.[77,78,79] DOE calculated marginal monthly regional energy prices by: (1) first estimating an average annual price for each region; (2) multiplying by monthly energy price factors, and (3) multiplying by seasonal marginal price factors for electricity, natural gas, and LPG. The analysis used historical data up to 2022 for residential and commercial natural gas and electricity prices and historical data up to 2021 for LPG and fuel oil prices. Further details may be found in chapter 8 of the final rule TSD.

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[77] U.S. Department of Energy-Energy Information Administration, Form EIA-861M (formerly EIA-826) detailed data (2022) (Available at: *www.eia.gov/electricity/data/eia861m/*) (Last accessed December 1, 2023).

[78] U.S. Department of Energy-Energy Information Administration, Natural Gas Navigator (2022) (Available at: *www.eia.gov/naturalgas/data.php*) (Last accessed December 1, 2023).

[79] U.S. Department of Energy-Energy Information Administration, State Energy Data System ("SEDS") (2021) (Available at: *www.eia.gov/state/seds/*) (Last accessed December 1, 2023).

GAAS argued that DOE has not fully responded to their previous suggestion of using the CMER (Consumer Marginal Energy Rates) method for energy prices. (GAAS, No. 1139 at p. 1)

DOE has evaluated other estimates of marginal energy prices but maintains its approach in the final rule, since the data used to develop those prices are nationally representative. Stakeholders have previously proposed alternative methods and data to estimate marginal natural gas prices. However, DOE compared its seasonal marginal price factors developed from the EIA data to marginal price factors for 23 gas tariffs provided by the Gas Technology Institute for the 2016 residential boilers energy conservation standards rulemaking. DOE found that the winter price factors used by DOE are generally comparable to those computed from the tariff data, indicating that DOE's marginal price estimates are reasonable at average usage levels. The summer price factors are also generally comparable. Of the 23 tariffs analyzed, eight have multiple tiers, and of these eight, six have ascending rates and two have descending rates. The tariff-based marginal factors use an average of the two tiers as the commodity price. A full tariff-based analysis would require information about the household's total baseline gas usage (to establish which tier the consumer is in), and a weight factor for each tariff that determines how many customers are served by that utility on that tariff. These data are generally not available in the public domain. DOE's use of EIA State-level data effectively averages overall consumer sales in each State, and so incorporates information from all utilities. DOE's approach is, therefore, more representative of a large group of consumers with diverse baseline gas usage levels than an approach that uses only tariffs. DOE notes that within a State, there could be significant variation in the marginal price factors, including differences between rural and urban rates. In order to take this to account, DOE developed marginal price factors for each individual household using RECS 2015 billing data. These data are then normalized to match the average State marginal price factors, which are equivalent to a consumption-weighted average marginal price across all households in the State. DOE's methodology allows energy prices to vary by sector, region and season. For more details on the comparative analysis and marginal price analysis, see appendix 8E of the final rule TSD.

To estimate energy prices in future years, DOE multiplied the 2022 energy prices by the projection of annual average price changes for each of the 50 U.S. states and District of Columbia from the reference case in *AEO2023*, which has an end year of 2050. [80] To estimate price trends after 2050, DOE used the average annual growth rate in prices from 2046 to 2050 based on the methods used in the 2022 Life-Cycle Costing Manual for the Federal Energy Management Program ("FEMP").[81]

AWHI suggested that the CA IOUs outline a price forecast scenario that more accurately accounts for future changes in energy costs. (AWHI, No. 1036 at p. 4) Gas Association Commenters argued that energy price assumptions from AEO are consistently overestimated and therefore should not be used (70% of the time was an overestimate for residential and 86% of the time was an overestimate for commercial sector between the 2010 and 2023 AEO projections). They argued that a distribution of

[80] EIA. *Annual Energy Outlook 2023 with Projections to 2050*. Washington, DC. Available at *www.eia.gov/forecasts/aeo/* (last accessed December 1, 2023).
[81] Lavappa, Priya D. and J. D. Kneifel. Energy Price Indices and Discount Factors for Life-Cycle Cost Analysis – 2022 Annual Supplement to NIST Handbook 135. National Institute of Standards and Technology (NIST). NISTIR 85-3273-37, available at www.nist.gov/publications/energy-price-indices-and-discount-factors-life-cycle-cost-analysis-2022-annual (last accessed December 1, 2023).

prices should be used and not a forecasted mean. (Gas Association Commenters, No. 1181 at p. 34) Rinnai stated that DOE's average and marginal consumer energy price forecasts (from EIA) for electricity and gaseous fuels have historically overstated prices (particularly for natural gas). Rinnai stated that DOE should instead use energy prices employed in the Federal Trade Commission ("FTC") Energy Guide labels because the uncertainty of applying forecasted prices shouldn't be primary drivers of LCC costs/savings and because FTC's use of AEO energy prices is audited annually and approved as published in the Federal Register prior to use for the EnergyGuide program. (Rinnai, No. 1186 at pp. 26-28) ONE Gas argued that consumer energy price forecasts from the *AEO* have been shown to be notoriously unreliable from forecasting year to forecasting year, and they systematically overpredict natural gas prices over time. (ONE Gas, No. 1200 at pp. 10-11) In response, DOE relies on AEO forecast for the energy price projection across appliance standards work as a cross-cutting methodology. Current energy prices are developed using other EIA data sources as described above. DOE acknowledges that it is difficult to project the future trend for any source given the uncertainty and unpredictability. However, AEO 2023 projects relatively flat energy price trends out to 2050 (see appendix 8E). AEO as issued by EIA remains the most comprehensive and trustworthy source and DOE maintains its methodology for this final rule. The energy prices developed for FTC are consistent with DOE's development of current energy prices (although here the analysis relies on marginal energy prices).

5. Maintenance and Repair Costs

Repair costs are associated with repairing or replacing product components that have failed in an appliance; maintenance costs are associated with maintaining the operation of the product. Typically, small incremental increases in product efficiency produce no, or only minor, changes in repair and maintenance costs compared to baseline efficiency products. DOE included additional maintenance and repair costs for higher efficiency consumer water heaters (including maintenance costs associated with condensate withdrawal, heat pump component filter cleaning, and deliming of the heat exchanger and repair costs associated with electronic ignition, controls, and blowers for fan-assisted designs, compressor, evaporator fan) based on 2023 RSMeans data.[82] DOE accounted for regional differences in labor costs by using RSMeans regional cost factors.

Ravnitzky stated that non-heat pump water heaters are less likely to require maintenance or repair than heat pump water heaters because they have a less complex design with fewer moving parts. (Ravnitzky, No. 73 at p. 1) Essency argued that maintenance costs are underestimated for heat pump water heaters because the lifetime of some components in heat pump water heaters will require replacements of parts once the heater is out of warranty. (Essency, No. 1194 at p. 3) Rheem voiced support for DOE's handling of operational and maintenance costs over the life of the water heater. (Rheem, No. 1177 at p. 9)

In response to Ravnitzky, research conducted by DOE has not shown that heat pump water heaters have different lifetimes than electric resistance storage water heaters. DOE has factored any additional maintenance or repair costs into the LCC. DOE takes into account replacement of certain parts after the warranty period. For the replacement of the heating element (which Essency provided as an example in its comment), the

[82] RSMeans Company, Inc., *RS Means Facilities Repair and Maintenance* (2023), available at *www.rsmeans.com/* (last accessed December 1, 2023).

replacement cost is accounted for the fraction where it occurs and annualized across the years of use. The repair and maintenance cost summary in the final rule TSD represents the average cost with some households experiencing more or less than the reported value.

6. Product Lifetime

Product lifetime is the age at which an appliance is retired from service. DOE conducted an analysis of water heater lifetimes based on the methodology described in a journal paper.[83] For this analysis, DOE relied on RECS 1990, 1993, 2001, 2005, 2009, 2015, and 2020.[84] DOE also used the U.S. Census's biennial American Housing Survey ("AHS"), from 1974-2021, which surveys all housing, noting the presence of a range of appliances.[85] DOE used the appliance age data from these surveys, as well as the historical water heater shipments, to generate an estimate of the survival function. The survival function provides a lifetime range from minimum to maximum, as well as an average lifetime. DOE estimates the average product lifetime to be around 15 years for storage water heaters.

Stanonik argued that increased average lifetimes for consumer storage water heaters are calculated estimates rather than based on field data thus leading to overstatements of average lifetime. Stanonik also argued that the increased complexity of

[83] Lutz, J., A. Hopkins, V. Letschert, V. Franco, and A. Sturges, Using national survey data to estimate lifetimes of residential appliances, *HVAC&R Research* (2011) 17(5): pp. 28 (Available at: *www.tandfonline.com/doi/abs/10.1080/10789669.2011.558166*) (Last accessed December 1, 2023).

[84] U.S. Department of Energy: Energy Information Administration, *Residential Energy Consumption Survey ("RECS")*, Multiple Years (1990, 1993, 1997, 2001, 2005, 2009, 2015, and 2020) (Available at: *www.eia.gov/consumption/residential/*) (Last accessed December 1, 2023).

[85] U.S. Census Bureau: Housing and Household Economic Statistics Division, *American Housing Survey,* Multiple Years (1974, 1975, 1976, 1977, 1978, 1979, 1980, 1981, 1983, 1985, 1987, 1989, 1991, 1993, 1995, 1997, 1999, 2001, 2003, 2005, 2007, 2009, 2011, 2013, 2015, 2017, 2019, and 2021) (Available at: *www.census.gov/programs-surveys/ahs/*) (Last accessed December 1, 2023).

newer products realistically would result in shorter lifetimes and more scenarios where "replace" might be a cheaper alternative than "repair," and that these scenarios are not reflected well in the analysis. (Stanonik, No. 1197 at p. 2) NMHC and NAA noted that AHRI assumes a 10-13 year lifespan for water heaters, which is less than DOE's estimated lifetime. (NMHC and NAA, No. 996 at p. 6) DOE has conducted an extensive literature review, including studies and surveys and warranty information, to determine its product lifetimes, as discussed in appendix 8G. DOE also utilizes Weibull distribution for the product lifetime to capture the field variations.

Noritz disputed that condensing and non-condensing products have the same average lifespan based on their internal testing. Noritz argued that the less complex nature of the non-condensing product in their testing typically lasts between 10 and 20 percent longer than a similar condensing product. Noritz argued that the analysis conducted by DOE that proposes the average lifespan of the two products to be identical will impact the LCC and payback analysis. (Noritz, No. 1202 at p. 3). In response, DOE has not found any evidence in its research pointing to a significantly different lifespan for the two types of water heaters. As described in appendix 8G, the data sources cited did not indicate any systematic decrease in lifetime for gas-fired condensing products. For this final rule, DOE maintains its methodology of assuming the same lifetime within product classes.

BWC noticed that the 2010 rulemaking reports an average lifetime of 13 years, rather than the assumed 15 years in the current rulemaking. BWC claimed that the lower product lifetime conclusions reached by DOE in the 2010 rulemaking appear to be more consistent with the evidence presented in the NOPR TSD. Specifically, in Figure 8G.4.6

in the TSD, the inflection points of the curves in this figure more closely align with the assumed product lifetimes established as part of DOE's 2010 rulemaking, and in the case of electric storage water heaters, indicate a product lifetime that is lower still. The assumed lifetime of 13 years for heat pump water heater products is also shared by the ENERGY STAR program in its materials that promote these products. BWC requested that DOE elaborate on the reason for an increase in product lifetimes from the assumptions deployed in the 2010 rulemaking to the longer product lifetimes assumed in the July 2023 NOPR. BWC also requested that DOE explain the apparent discrepancies between the graphic demonstration of product lifetimes in 8G.4.6 and those expressed in Table 8G.4.1. (BWC, No. 1164 at pp. 3-4)

From the 2010 Final Rule to this rulemaking, DOE was able to collect more evidence from literature review on product lifetime as well as develop a more robust survival function to calculate the lifetimes. Regarding the figure in the NOPR TSD, the inflection point represents the lifetime most water heaters will live to, whereas the average takes into account those who live an unusually short or long lifetime. The lifetime distribution in this rulemaking, compared to that of the 2010 rulemaking, has an early start, taking into account those that retire starting from year two, and a longer tail, allowing some water heaters to survive much longer than average. DOE believes that it is beneficial to capture the variations in lifetime and thus maintain its methodology in this final rule.

BWC expressed support for DOE conducting a sensitivity analysis for all water heater product classes, as they claimed this is an effective way for this rulemaking to account for the reality that product lifetimes are not constant across efficiency levels and decrease with increased efficiency and complexity of a system. (BWC, No. 1164 at p. 4) In order to evaluate the impact of the lifetime on the economic analysis results, for this final rule DOE conducted a sensitivity analysis, where two additional lifetime scenarios were evaluated. The sensitivity results do not change DOE's conclusion of economic justification of the adopted standards (see appendix 8G of the final rule TSD for the comparison of results).

7. Discount Rates

In the calculation of LCC, DOE applies discount rates appropriate to households to estimate the present value of future operating cost savings. DOE estimated a distribution of discount rates for consumer water heaters based on the opportunity cost of consumer funds.

DOE applies weighted average discount rates calculated from consumer debt and asset data, rather than marginal or implicit discount rates.[86] The LCC analysis estimates net present value over the lifetime of the product, so the appropriate discount rate will reflect the general opportunity cost of household funds, taking this time scale into account. Given the long time horizon modeled in the LCC analysis, the application of a marginal interest rate associated with an initial source of funds is inaccurate. Regardless of the method of purchase, consumers are expected to continue to rebalance their debt

[86] The implicit discount rate is inferred from a consumer purchase decision between two otherwise identical goods with different first cost and operating cost. It is the interest rate that equates the increment of first cost to the difference in net present value of lifetime operating cost, incorporating the influence of several factors: transaction costs; risk premiums and response to uncertainty; time preferences; interest rates at which a consumer is able to borrow or lend. The implicit discount rate is not appropriate for the LCC analysis because it reflects a range of factors that influence consumer purchase decisions, rather than the opportunity cost of the funds that are used in purchases.

and asset holdings over the LCC analysis period, based on the restrictions consumers face in their debt payment requirements and the relative size of the interest rates available on debts and assets. DOE estimates the aggregate impact of this rebalancing using the historical distribution of debts and assets.

To establish residential discount rates for the LCC analysis, DOE identified all relevant household debt or asset classes in order to approximate a consumer's opportunity cost of funds related to appliance energy cost savings. It estimated the average percentage shares of the various types of debt and equity by household income group using data from the Federal Reserve Board's triennial Survey of Consumer Finances[87] ("SCF") starting in 1995 and ending in 2019. Using the SCF and other sources, DOE developed a distribution of rates for each type of debt and asset by income group to represent the rates that may apply in the year in which amended standards would take effect. DOE assigned each sample household a specific discount rate drawn from one of the distributions. The average rate across all types of household debt and equity and income groups, weighted by market share of each product class, is 4.2 percent. See chapter 8 of the final rule TSD for further details on the development of consumer discount rates.

To establish commercial discount rates for the small fraction of consumer water heaters installed in commercial buildings, DOE estimated the weighted-average cost of

[87] The Federal Reserve Board, *Survey of Consumer Finances* (1995, 1998, 2001, 2004, 2007, 2010, 2013, 2016, and 2019) (Available at: *www.federalreserve.gov/econres/scfindex.htm*) (last accessed Dec. 1, 2023). The Federal Reserve Board is currently processing the 2022 Survey of Consumer Finances, which is expected to be fully available in late 2023.

capital using data from Damodaran Online.[88] The weighted-average cost of capital is commonly used to estimate the present value of cash flows to be derived from a typical company project or investment. Most companies use both debt and equity capital to fund investments, so their cost of capital is the weighted average of the cost to the firm of equity and debt financing. DOE estimated the cost of equity using the capital asset pricing model, which assumes that the cost of equity for a particular company is proportional to the systematic risk faced by that company. DOE's commercial discount rate approach is based on the methodology described in a Lawrence Berkeley National Laboratory report, and the distribution varies by business activity.[89] The average rate for consumer water heaters used in commercial applications in this final rule analysis, across all business activity and weighted by the market share of each product class, is 6.9 percent.

See chapter 8 of this final rule TSD for further details on the development of consumer and commercial discount rates.

8. Energy Efficiency Distribution in the No-New-Standards Case

To accurately estimate the share of consumers that would be affected by a potential energy conservation standard at a particular efficiency level, DOE's LCC analysis considered the projected distribution (market shares) of product efficiencies under the no-new-standards case (*i.e.*, the case without amended or new energy

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[88] Damodaran Online, Data Page: Costs of Capital by Industry Sector (2021) (Available at: pages.stern.nyu.edu/~adamodar/) (Last accessed December 1, 2023).
[89] Fujita, S., Commercial, Industrial, and Institutional Discount Rate Estimation for Efficiency Standards Analysis: Sector-Level Data 1998 – 2018 (Available at: *ees.lbl.gov/publications/commercial-industrial-and*) (Last accessed December 1, 2023).

conservation standards). This approach reflects the fact that some consumers may purchase products with efficiencies greater than the baseline levels.

To estimate the energy efficiency distribution of consumer water heaters for 2030, DOE used available shipments data by efficiency including in previous AHRI submitted historical shipment data,[90] ENERGY STAR unit shipments data,[91] and data from a 2023 BRG Building Solutions report. [92] To cover gaps in the available shipments data, DOE used DOE's public CCD model database[93] and AHRI certification directory.[94]

The estimated market shares for the no-new-standards case for consumer water heaters are shown in Table IV.26. See chapter 8 of the final rule TSD for further information on the derivation of the efficiency distributions.

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[90] AHRI. Gas-fired and Electric Storage Water Heater Shipments Data to DOE. March 11, 2008; AHRI. Gas-fired Storage Heater Shipments Data to DOE. March 18, 2009.

[91] ENERGY STAR. Unit Shipments data 2010-2021. multiple reports. (Available at: *www.energystar.gov/partner_resources/products_partner_resources/brand_owner_resources/unit_shipment_data*) (Last accessed December 1, 2023).

[92] BRG Building Solutions. The North American Heating & Cooling Product Markets (2023 Edition). 2023.

[93] U.S. Department of Energy's Compliance Certification Database is available at *regulations.doe.gov/certification-data* (last accessed Dec. 1, 2023).

[94] Air Conditioning Heating and Refrigeration Institute. Consumer's Directory of Certified Efficiency Ratings for Heating and Water Heating Equipment. May 16, 2023. (Available at *www.ahridirectory.org*) (Last accessed December 1, 2023).

Table IV.26 No-New-Standards Case Energy Efficiency Distributions in 2030 for Consumer Water Heaters

Efficiency Level	Draw Pattern					
	Low		Medium		High	
	UEF*	Market Share *(%)*	UEF*	Market Share *(%)*	UEF*	Market Share *(%)*
Gas-Fired Storage Water Heaters, ≥20 gal and ≤55 gal						
0	0.54	52%	0.58	57%	0.63	56%
1	0.57	25%	0.60	22%	0.64	22%
2	0.59	4%	0.64	5%	0.68	5%
3	0.60	19%	0.65	14%	0.69	15%
4	0.71	0%	0.75	1%	0.80	1%
5	0.77	0%	0.81	1%	0.88	1%
Oil-Fired Storage Water Heaters, ≤50 gal						
0					0.64	67%
1					0.66	17%
2					0.68	17%
Small Electric Storage Water Heaters, ≥20 gal and ≤35 gal and FHR < 51 gal						
0	0.91/0.92**	99.0				
1	2.00	1.0				
Electric Storage Water Heaters, ≥20 gal and ≤55 gal, excluding Small ESWHs						
0	0.91	88%	0.92	88%	0.93	84%
1	2.30	1%	2.30	1%	2.30	1%
2	3.29	8%	3.35	7%	3.47	10%
3	3.69	3%	3.75	4%	3.87	5%
Electric Storage Water Heaters, >55 gal and ≤120 gal						
0			2.05	4%	2.15	4%
1			2.50	11%	2.50	12%
2			3.35	75%	3.45	74%
3			3.90	10%	4.00	11%

* UEF at the representative rated capacity.
** 0.91 UEF at 30 gallon effective storage volume and 0.92 UEF at 35 gallon effective storage volume.

The LCC Monte Carlo simulations draw from the efficiency distributions and assign an efficiency to the water heater purchased by each sample household in the no-new-standards case according to these distributions.

Finally, DOE considered the 2019 AHCS survey,[95] which includes questions to recent purchasers of HVAC equipment regarding the perceived efficiency of their

[95] Decision Analysts, 2019 American Home Comfort Studies (Available at: *www.decisionanalyst.com/Syndicated/HomeComfort/*) (Last accessed January 5, 2024).

equipment (Standard, High, and Super High Efficiency), as well as questions related to various household and demographic characteristics. DOE did not find similar data for consumer water heaters, but believes that the HVAC data is relevant to other larger appliances such as consumer water heaters since they similarly represent large energy end uses. From these data, DOE found that households with larger square footage exhibited a higher fraction of High- or Super-High efficiency equipment installed. The fraction of respondents with "super high efficiency" equipment was larger by approximately 5 percent for larger households and correspondingly smaller for smaller households. DOE therefore used the AHCS data to adjust its water heater efficiency distributions as follows: (1) the market share of higher efficiency equipment for households under 1,500 sq. ft. was decreased by 5 percentage points; and (2) the market share of condensing equipment for households above 2,500 sq. ft. was increased by 5 percentage points.

DOE acknowledges that economic factors may play a role when consumers, commercial building owners, or builders decide on what type of water heater to install. However, assignment of water heater efficiency for a given installation based solely on economic measures such as life-cycle cost or simple payback period most likely would not fully and accurately reflect actual real-world installations. There are a number of market failures discussed in the economics literature that illustrate how purchasing decisions with respect to energy efficiency are unlikely to be perfectly correlated with energy use, as described below. While this literature is not specific to water heaters, DOE finds that the method of assignment, which is in part random, simulates behavior in the water heater market, where market failures and other consumer preferences result in purchasing decisions not being perfectly aligned with economic interests, more realistically than relying only on apparent cost-effectiveness criteria derived from the limited information in CBECS or RECS. DOE further emphasizes that its approach does not assume that all purchasers of water heaters make economically irrational decisions (*i.e.*, the lack of a correlation is not the same as a negative correlation). As part of the random assignment, some homes or buildings with large hot water use will be assigned higher efficiency water heaters, and some homes or buildings with particularly low hot water use will be assigned baseline water heaters. By using this approach, DOE acknowledges the variety of market failures and other consumer behaviors present in the water heater market, and does not assume certain market conditions unsupported by the available evidence.

First, consumers are motivated by more than simple financial trade-offs. There are consumers who are willing to pay a premium for more energy-efficient products because they are environmentally conscious.[96] There are also several behavioral factors that can influence the purchasing decisions of complicated multi-attribute products, such as water heaters. For example, consumers (or decision makers in an organization) are highly influenced by choice architecture, defined as the framing of the decision, the surrounding circumstances of the purchase, the alternatives available, and how they're presented for any given choice scenario.[97] The same consumer or decision maker may make different choices depending on the characteristics of the decision context (*e.g.*, the timing of the purchase, competing demands for funds), which have nothing to do with the

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[96] Ward, D. O., Clark, C. D., Jensen, K. L., Yen, S. T., & Russell, C. S. (2011): "Factors influencing willingness-to pay for the ENERGY STAR® label," *Energy Policy*, *39*(3), 1450-1458. (Available at: w*ww.sciencedirect.com/science/article/abs/pii/S0301421510009171*) (Last accessed January 5, 2024).

[97] Thaler, R.H., Sunstein, C.R., and Balz, J.P. (2014). "Choice Architecture" in *The Behavioral Foundations of Public Policy*, Eldar Shafir (ed).

characteristics of the alternatives themselves or their prices. Consumers or decision makers also face a variety of other behavioral phenomena including loss aversion, sensitivity to information salience, and other forms of bounded rationality.[98] R.H. Thaler, who won the Nobel Prize in Economics in 2017 for his contributions to behavioral economics, and Sunstein point out that these behavioral factors are strongest when the decisions are complex and infrequent, when feedback on the decision is muted and slow, and when there is a high degree of information asymmetry.[99] These characteristics describe almost all purchasing situations of appliances and equipment, including water heaters. The installation of a new or replacement water heater is done infrequently, as evidenced by the mean lifetime for water heaters. Additionally, it would take at least one full water heating season for any impacts on operating costs to be fully apparent. Further, if the purchaser of the water heater is not the entity paying the energy costs (*e.g.,* a building owner and tenant), there may be little to no feedback on the purchase. Additionally, there are systematic market failures that are likely to contribute further complexity to how products are chosen by consumers, as explained in the following paragraphs.

The first of these market failures—the split-incentive or principal-agent problem—is likely to affect water heaters more than many other types of appliances. The principal-agent problem is a market failure that results when the consumer that purchases

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[98] Thaler, R.H., and Bernartzi, S. (2004). "Save More Tomorrow: Using Behavioral Economics in Increase Employee Savings," *Journal of Political Economy* 112(1), S164-S187. *See also* Klemick, H., et al. (2015) "Heavy-Duty Trucking and the Energy Efficiency Paradox: Evidence from Focus Groups and Interviews," *Transportation Research Part A: Policy & Practice*, 77, 154-166. (providing evidence that loss aversion and other market failures can affect otherwise profit-maximizing firms).

[99] Thaler, R.H., and Sunstein, C.R. (2008). Nudge: Improving Decisions on Health, Wealth, and Happiness. New Haven, CT: Yale University Press.

the equipment does not internalize all of the costs associated with operating the equipment. Instead, the user of the product, who has no control over the purchase decision, pays the operating costs. There is a high likelihood of split incentive problems in the case of rental properties where the landlord makes the choice of what water heater to install, whereas the renter is responsible for paying energy bills. In the LCC sample, a significant fraction of households with a water heater are renters. For example, for the medium electric storage water heaters LCC sample, nearly 30 percent of households are renters, whereas for the small electric storage water heater LCC sample, nearly 50 percent of households are renters. These fractions are significantly higher for low-income households (see section IV.I of this document and chapter 11 of the final rule TSD). The principle-agent problem can also impact homeowners. For example, in new construction, builders influence the type of water heater used in many homes but do not pay operating costs. Finally, contractors install a large share of water heaters in replacement situations, and they can exert a high degree of influence over the type of water heater purchased based on which products they are familiar with.

In addition to the split-incentive problem, there are other market failures that are likely to affect the choice of water heater efficiency made by consumers. For example, emergency replacements of essential equipment such as water heaters are strongly biased toward like-for-like replacement (*i.e.*, replacing the non-functioning equipment with a similar or identical product). Time is a constraining factor during emergency replacements and it may not be possible to consider the full range of available options on the market. The consideration of alternative product options is far more likely for planned replacements and installations in new construction.

Additionally, Davis and Metcalf[100] conducted an experiment demonstrating that the nature of the information available to consumers from EnergyGuide labels posted on air conditioning equipment results in an inefficient allocation of energy efficiency across households with different usage levels. Their findings indicate that households are likely to make decisions regarding the efficiency of the climate control equipment of their homes that do not result in the highest net present value for their specific usage pattern (*i.e.*, their decision is based on imperfect information and, therefore, is not necessarily optimal).

In part because of the way information is presented, and in part because of the way consumers process information, there is also a market failure consisting of a systematic bias in the perception of equipment energy usage, which can affect consumer choices. Attari, et al.[101] show that consumers tend to underestimate the energy use of large energy-intensive appliances but overestimate the energy use of small appliances. Water heaters are one of the largest energy-consuming end-uses in a home. Therefore, it is likely that consumers systematically underestimate the energy use associated with water heater, resulting in less cost-effective water heater purchases.

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[100] Davis, L. W., and G. E. Metcalf (2016): "Does better information lead to better choices? Evidence from energy-efficiency labels," *Journal of the Association of Environmental and Resource Economists*, 3(3), 589-625. (Available at: *www.journals.uchicago.edu/doi/full/10.1086/686252*) (Last accessed January 5, 2024).

[101] Attari, S. Z., M.L. DeKay, C.I. Davidson, and W. Bruine de Bruin (2010): "Public perceptions of energy consumption and savings." *Proceedings of the National Academy of Sciences* 107(37), 16054-16059 (Available at: *www.pnas.org/content/107/37/16054*) (Last accessed January 5, 2024).

These market failures may affect a sizeable share of the consumer population. A study by Houde[102] indicates that there is a significant subset of consumers that appear to purchase appliances without taking into account their energy efficiency and operating costs at all, though subsequent studies using alternative methodologies have highlighted other consumer groups who are to some extent responsive to local energy prices with their appliance purchases.[103] The extent to which consumers are perceptive of energy prices and product efficiency when making appliance purchasing decisions is a topic of ongoing research.

Although consumer water heaters are predominantly installed in the residential sector, some are also installed in commercial buildings (less than 10 percent of projected shipments; see chapter 9 of the final rule TSD). There are market failures relevant to consumer water heaters installed in commercial applications as well. It is often assumed that because commercial and industrial customers are businesses that have trained or experienced individuals making decisions regarding investments in cost-saving measures, some of the commonly observed market failures present in the general population of residential customers should not be as prevalent in a commercial setting. However, there are many characteristics of organizational structure and historic circumstance in commercial settings that can lead to underinvestment in energy efficiency.

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[102] Houde, S. (2018): "How Consumers Respond to Environmental Certification and the Value of Energy Information," *The RAND Journal of Economics*, 49 (2), 453-477 (Available at: *onlinelibrary.wiley.com/doi/full/10.1111/1756-2171.12231*) (Last accessed January 5, 2024).
[103] Houde, S. and Meyers, E. (2021). "Are consumers attentive to local energy costs? Evidence from the appliance market," Journal of Public Economics, 2011 (Available at: *sciencedirect.com/science/article/pii/S004727272100116X*) (Last accessed March 7, 2024).

First, a recognized problem in commercial settings is the principal-agent problem, where the building owner (or building developer) selects the equipment and the tenant (or subsequent building owner) pays for energy costs.[104, 105] Indeed, more than a quarter of commercial buildings in the CBECS 2018 sample are occupied at least in part by a tenant, not the building owner (indicating that, in DOE's experience, the building owner in some cases is not responsible for paying energy costs). Additionally, some commercial buildings have multiple tenants. There are other similar misaligned incentives embedded in the organizational structure within a given firm or business that can impact the choice of a water heater. For example, if one department or individual within an organization is responsible for capital expenditures (and therefore equipment selection) while a separate department or individual is responsible for paying the energy bills, a market failure similar to the principal-agent problem can result.[106] Additionally, managers may have other responsibilities and often have other incentives besides operating cost minimization, such as satisfying shareholder expectations, which can sometimes be focused on short-term returns.[107] Decision-making related to commercial buildings is highly complex and involves gathering information from and for a variety of

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[104] Vernon, D., and Meier, A. (2012). "Identification and quantification of principal–agent problems affecting energy efficiency investments and use decisions in the trucking industry," *Energy Policy*, 49, 266-273.
[105] Blum, H. and Sathaye, J. (2010). "Quantitative Analysis of the Principal-Agent Problem in Commercial Buildings in the U.S.: Focus on Central Space Heating and Cooling," Lawrence Berkeley National Laboratory, LBNL-3557E. (Available at: *escholarship.org/uc/item/6p1525mg*) (Last accessed January 5, 2024).
[106] Prindle, B., Sathaye, J., Murtishaw, S., Crossley, D., Watt, G., Hughes, J., and de Visser, E. (2007). "Quantifying the effects of market failures in the end-use of energy," Final Draft Report Prepared for International Energy Agency. (Available from International Energy Agency, Head of Publications Service, 9 rue de la Federation, 75739 Paris, Cedex 15 France).
[107] Bushee, B. J. (1998). "The influence of institutional investors on myopic R&D investment behavior," *Accounting Review*, 305-333.
DeCanio, S.J. (1993). "Barriers Within Firms to Energy Efficient Investments," *Energy Policy*, 21(9), 906–914. (explaining the connection between short-termism and underinvestment in energy efficiency).

different market actors. It is common to see conflicting goals across various actors within the same organization as well as information asymmetries between market actors in the energy efficiency context in commercial building construction.[108]

Second, the nature of the organizational structure and design can influence priorities for capital budgeting, resulting in choices that do not necessarily maximize profitability.[109] Even factors as simple as unmotivated staff or lack of priority-setting and/or a lack of a long-term energy strategy can have a sizable effect on the likelihood that an energy efficient investment will be undertaken.[110] U.S. tax rules for commercial buildings may incentivize lower capital expenditures, since capital costs must be

[108] International Energy Agency (IEA). (2007). Mind the Gap: Quantifying Principal-Agent Problems in Energy Efficiency. OECD Pub. (Available at: *www.iea.org/reports/mind-the-gap*) (Last accessed January 5, 2024)

[109] DeCanio, S. J. (1994). "Agency and control problems in US corporations: the case of energy-efficient investment projects," *Journal of the Economics of Business*, 1(1), 105-124.
Stole, L. A., and Zwiebel, J. (1996). "Organizational design and technology choice under intrafirm bargaining," *The American Economic Review*, 195-222.

[110] Rohdin, P., and Thollander, P. (2006). "Barriers to and driving forces for energy efficiency in the non-energy intensive manufacturing industry in Sweden," *Energy*, 31(12), 1836-1844.
Takahashi, M and Asano, H (2007). "Energy Use Affected by Principal-Agent Problem in Japanese Commercial Office Space Leasing," In *Quantifying the Effects of Market Failures in the End-Use of Energy*. American Council for an Energy-Efficient Economy. February 2007.
Visser, E and Harmelink, M (2007). "The Case of Energy Use in Commercial Offices in the Netherlands," In *Quantifying the Effects of Market Failures in the End-Use of Energy*. American Council for an Energy-Efficient Economy. February 2007.
Bjorndalen, J. and Bugge, J. (2007). "Market Barriers Related to Commercial Office Space Leasing in Norway," In *Quantifying the Effects of Market Failures in the End-Use of Energy*. American Council for an Energy-Efficient Economy. February 2007.
Schleich, J. (2009). "Barriers to energy efficiency: A comparison across the German commercial and services sector," *Ecological Economics*, 68(7), 2150-2159.
Muthulingam, S., et al. (2013). "Energy Efficiency in Small and Medium-Sized Manufacturing Firms," *Manufacturing & Service Operations Management*, 15(4), 596-612. (Finding that manager inattention contributed to the non-adoption of energy efficiency initiatives).
Boyd, G.A., Curtis, E.M. (2014). "Evidence of an 'energy management gap' in US manufacturing: Spillovers from firm management practices to energy efficiency," *Journal of Environmental Economics and Management*, 68(3), 463-479.

depreciated over many years, whereas operating costs can be fully deducted from taxable income or passed through directly to building tenants.[111]

Third, there are asymmetric information and other potential market failures in financial markets in general, which can affect decisions by firms with regard to their choice among alternative investment options, with energy efficiency being one such option.[112] Asymmetric information in financial markets is particularly pronounced with regard to energy efficiency investments.[113] There is a dearth of information about risk and volatility related to energy efficiency investments, and energy efficiency investment metrics may not be as visible to investment managers,[114] which can bias firms towards more certain or familiar options. This market failure results not because the returns from energy efficiency as an investment are inherently riskier, but because information about the risk itself tends not to be available in the same way it is for other types of investment, like stocks or bonds. In some cases energy efficiency is not a formal investment category

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[111] Lovins, A. (1992). Energy-Efficient Buildings: Institutional Barriers and Opportunities. (Available at: *rmi.org/insight/energy-efficient-buildings-institutional-barriers-and-opportunities/*) (Last accessed January 5, 2024).

Fazzari, S. M., Hubbard, R. G., Petersen, B. C., Blinder, A. S., and Poterba, J. M. (1988). "Financing constraints and corporate investment," *Brookings Papers on Economic Activity*, 1988(1), 141-206.

Cummins, J. G., Hassett, K. A., Hubbard, R. G., Hall, R. E., and Caballero, R. J. (1994). "A reconsideration of investment behavior using tax reforms as natural experiments," *Brookings Papers on Economic Activity*, 1994(2), 1-74.

DeCanio, S. J., and Watkins, W. E. (1998). "Investment in energy efficiency: do the characteristics of firms matter?" *Review of Economics and Statistics*, 80(1), 95-107.

Hubbard R.G. and Kashyap A. (1992). "Internal Net Worth and the Investment Process: An Application to U.S. Agriculture," *Journal of Political Economy,* 100, 506-534.

[113] Mills, E., Kromer, S., Weiss, G., and Mathew, P. A. (2006). "From volatility to value: analysing and managing financial and performance risk in energy savings projects," *Energy Policy*, 34(2), 188-199.

Jollands, N., Waide, P., Ellis, M., Onoda, T., Laustsen, J., Tanaka, K., and Meier, A. (2010). "The 25 IEA energy efficiency policy recommendations to the G8 Gleneagles Plan of Action," *Energy Policy*, 38(11), 6409-6418.

[114] Reed, J. H., Johnson, K., Riggert, J., and Oh, A. D. (2004). "Who plays and who decides: The structure and operation of the commercial building market," U.S. Department of Energy Office of Building Technology, State and Community Programs. (Available at: *www1.eere.energy.gov/buildings/publications/pdfs/commercial_initiative/who_plays_who_decides.pdf*) (Last accessed January 5, 2024).

used by financial managers, and if there is a formal category for energy efficiency within the investment portfolio options assessed by financial managers, they are seen as weakly strategic and not seen as likely to increase competitive advantage.[115] This information asymmetry extends to commercial investors, lenders, and real-estate financing, which is biased against new and perhaps unfamiliar technology (even though it may be economically beneficial).[116] Another market failure known as the first-mover disadvantage can exacerbate this bias against adopting new technologies, as the successful integration of new technology in a particular context by one actor generates information about cost-savings, and other actors in the market can then benefit from that information by following suit; yet because the first to adopt a new technology bears the risk but cannot keep to themselves all the informational benefits, firms may inefficiently underinvest in new technologies.[117]

In sum, the commercial and industrial sectors face many market failures that can result in an under-investment in energy efficiency. This means that discount rates implied by hurdle rates[118] and required payback periods of many firms are higher than the appropriate cost of capital for the investment.[119] The preceding arguments for the existence of market failures in the commercial and industrial sectors are corroborated by

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[115] Cooremans, C. (2012). "Investment in energy efficiency: do the characteristics of investments matter?" *Energy Efficiency*, 5(4), 497-518.
[116] Lovins 1992, op. cit.
The Atmospheric Fund. (2017). Money on the table: Why investors miss out on the energy efficiency market. (Available at: *taf.ca/publications/money-table-investors-energy-efficiency-market/*) (Last accessed January 5, 2024).
[117] Blumstein, C. and Taylor, M. (2013). Rethinking the Energy-Efficiency Gap: Producers, Intermediaries, and Innovation. Energy Institute at Haas Working Paper 243. (Available at: *haas.berkeley.edu/wp-content/uploads/WP243.pdf*) (Last accessed January 5, 2024).
[118] A hurdle rate is the minimum rate of return on a project or investment required by an organization or investor. It is determined by assessing capital costs, operating costs, and an estimate of risks and opportunities.
[119] DeCanio 1994, op. cit.

empirical evidence. One study in particular showed evidence of substantial gains in energy efficiency that could have been achieved without negative repercussions on profitability, but the investments had not been undertaken by firms.[120] The study found that multiple organizational and institutional factors caused firms to require shorter payback periods and higher returns than the cost of capital for alternative investments of similar risk. Another study demonstrated similar results with firms requiring very short payback periods of 1-2 years in order to adopt energy-saving projects, implying hurdle rates of 50 to 100 percent, despite the potential economic benefits.[121] A number of other case studies similarly demonstrate the existence of market failures preventing the adoption of energy-efficient technologies in a variety of commercial sectors around the world, including office buildings,[122] supermarkets,[123] and the electric motor market.[124]

The existence of market failures in the residential and commercial sectors is well supported by the economics literature and by a number of case studies. Although these studies are not specifically targeted to the water heater market, they cover decision-making generally and the impact of energy efficiency, operating costs, and future savings/expenditures on those decisions, all of which apply to the purchase of a consumer

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[120] DeCanio, S. J. (1998). "The Efficiency Paradox: Bureaucratic and Organizational Barriers to Profitable Energy-Saving Investments," *Energy Policy*, 26(5), 441-454.
[121] Andersen, S.T., and Newell, R.G. (2004). "Information programs for technology adoption: the case of energy-efficiency audits," *Resource and Energy Economics*, 26, 27-50.
[122] Prindle 2007, op. cit.
Howarth, R.B., Haddad, B.M., and Paton, B. (2000). "The economics of energy efficiency: insights from voluntary participation programs," *Energy Policy*, 28, 477-486.
[123] Klemick, H., Kopits, E., Wolverton, A. (2017). "Potential Barriers to Improving Energy Efficiency in Commercial Buildings: The Case of Supermarket Refrigeration," *Journal of Benefit-Cost Analysis*, 8(1), 115-145.
[124] de Almeida, E.L.F. (1998). "Energy efficiency and the limits of market forces: The example of the electric motor market in France", *Energy Policy*, 26(8), 643-653.
Xenergy, Inc. (1998). United States Industrial Electric Motor Systems Market Opportunity Assessment. (Available at: *www.energy.gov/sites/default/files/2014/04/f15/mtrmkt.pdf*) (Last accessed January 5, 2024).

water heater. DOE is not aware of any market failure studies specifically and narrowly focused on water heaters and so relies on the available literature discussed above. If DOE developed an efficiency distribution that assigned water heater efficiency in the no-new-standards case solely according to energy use or economic considerations such as life-cycle cost or payback period, the resulting distribution of efficiencies within the building sample would not reflect any of the market failures or behavioral factors above. DOE thus concludes such a distribution would not be representative of the water heater market.

DOE further notes that, in the case of gas-fired storage, oil-fired storage, and electric storage water heaters (≤55 gal), the distribution of efficiency in the current market is heavily weighted toward baseline efficiency or efficiency at EL 1. Accordingly, in the no new-standards case, most consumers are assigned EL 0 or EL 1 in accordance with the market data. As a result, any variation to DOE's efficiency assignment methodology will not produce substantially differing results than presented in this final rule, as most consumers will continue to be assigned the same efficiency regardless of the details of the methodology. In other words, as most consumers in the storage water heater market are choosing baseline or near-baseline efficiency products, there would be no significant difference between a random assignment of those efficiency levels to consumers as to another type of assignment methodology such as one that tried to consider consumer rationality more explicitly - in either case nearly every individual consumer would be assigned a baseline or near-baseline efficiency product. This may be in contrast to a product with a broad distribution of efficiency levels purchased in the market, where changing the assignment methodology could more significantly impact the assignment of an efficiency level to individual consumers and therefore impact the results.

Gas Association Commenters and Atmos Energy argued that random assignment methodology is unreasonable because it overstates standards-compliant outcomes in the base case by capturing decisions that consumers would naturally choose on their own for economically beneficial reasons and it understates outcomes in the rule case by disproportionately including unattractive economic outcomes. Gas Association Commenters argued that consumer economic preference is not accounted for in random assignments, and argued that consumer choice models, which were used for fuel switching scenarios in gas furnaces, should be used in water heaters. Gas Association Commenters argued that random assignment creates extreme examples of economic benefits and consequences that heavily skew averages and are the least realistic outcomes as they would be the most obvious economic consumer choice. Gas Association Commenters argued that DOE has cases in their analysis where a standards-compliant product is the cheapest option but because of random assignment, a less-efficient, more expensive option is initially assigned, skewing benefits for rule scenarios. In its comment, Gas Association Commenters proposed alternatives to random assignment. (Gas Association Commenters, No. 1181 at p. 10 and pp. 11-23; Atmos Energy, No. 1183 at pp. 6-7) Rinnai argued that DOE has not yet addressed the central criticism of the random assignment of base case efficiencies which is that DOE has not justified through either correlation or causation of random assignment to the alleged market failures it represents. Rinnai argued that there are many better alternate approaches to solving market failures beyond appliance standards. Rinnai argued that base case random assignment implies that consumers only make rational economic decisions in rulemaking scenarios. Rinnai argued many of the same points made in other comments already mentioned in this document; namely: consumers in base case choosing worse efficiency products even when doing so is more expensive; highly favorable economic outcomes that skew results; base case irrationality versus rulemaking case rational economic decision making. (Rinnai, No. 1186 at pp. 31-33)

ONE Gas argued that in its comments that past issues of random assignment of consumers to appliance purchase decisions in the base case life cycle cost analysis has been an enduringly contentious issue with the Department's TSD approach, and the Department appears to have not undertaken measures to address stakeholder concerns of that kind. ONE Gas noted that more detailed review of this issue by industry stakeholders is ongoing. ONE Gas argued that the Department has never presented analysis that justifies linkages between market failure and random purchase behavior and no evidence is provided in the Preliminary Analysis TSD document that the Department has included additional consideration of NASEM peer review recommendation that calls on the Department to improve its coverage of market failure in relation to the setting of appliance minimum efficiency standards. ONE Gas proposed to the Department that it use alternative means of defining consumer base case efficiencies based upon one of two of the following base case definition strategies for consumer simulations: correlated consumer attributes approach or rational consumer economic choice approach. (ONE Gas, No. 1200 at pp. 11-12) NPGA, APGA, AGA, and Rinnai noted that DOE's response to comments on its failing to address consumer choice and to account for consumers making choices based on rational economic terms in the July 2023 NOPR is arbitrary, capricious, and without foundation. NPGA, APGA, AGA, and Rinnai commented that instead of referencing actual interviews or studies, DOE pivoted to a "cherry-picked" library of behavioral economics papers that have no bearing or relevance to water heaters or the proposed rule. (NPGA, APGA, AGA, and Rinnai, No. 441 at p. 4) AHRI recommended that DOE provide a theory of market performance tailored to the specific situation for each and every rulemaking. AHRI commented that DOE should build an analytical approach that reflects some degree of market efficiency, rather than assuming complete market efficiency. AHRI acknowledges that this may necessitate a rethinking of the Monte Carlo method and the assignment of base and standard case efficiencies. (AHRI, No. 1167 at p. 17) AHRI highlighted that AHRI demonstrated there are ways to use the current Monte Carlo approach to generate results and then use alternative ranking systems to assign base and standards case efficiencies. (AHRI, No. 1167 at p. 18) AHRI commented that DOE misunderstands the role of plumbing contractors in the decision process and DOE implies that the influence of plumbing contractors on water heater type purchased in the replacement scenario is a form of market failure. AHRI claimed this is incorrect as contractors serve as the information mediators to overcome one of the key sources of possible market failure identified by DOE – the absence of knowledge from consumers who rarely purchase water heaters. (AHRI, No. 1167 at p. 18) AHRI posed the following questions for DOE related to market failure: "Why has DOE not adopted the National Academies of Sciences (NAS) peer review recommendations and when will it do so? On what basis has DOE determined that there are significant market failures for residential water heaters, how prevalent are these failures and do standards address them? How will DOE modify its random assignment approach to be more responsive to actual market conditions?" (AHRI, No. 1167 at p. 18) Gas Association Commenters argued the tab "No-New Standards Case UEF" of the analysis tool incorrectly states an equation (relative to the coded version) for how square footage of residences impacts likelihood of efficiency of products. (Gas Association Commenters, No. 1181 at p. 35) Gas Association Commenters argued that adjustment factors used based on square footage do not make sense for this analysis and instead size of household should be used. (Gas Association Commenters, No. 1181 at p. 35) Gas Association Commenters argued that estimated fractions of shipments by market shares do not exactly match the stated distributions (see specifics in comment). (Gas Association Commenters, No. 1181 at p. 35) ONE Gas commented that, unlike many other products covered by EPCA, consumers rarely have opportunity to consider other water heating options when hot water is unavailable in a residence, a premium exists to restore service, especially since water heater failure is rarely anticipated by an average consumer; when time or other circumstances allow, the consumer is likely to make a rational consumer choice based, first and foremost, on minimizing installed cost; life cycle cost considerations and other factors play a role in decision making, provided comparative installed costs are available to the consumer. (ONE Gas, No. 1200 at p. 5)

In response, DOE notes that even for consumers who are motivated and informed, the choice of product efficiency that perfectly minimizes life-cycle cost is highly nuanced and requires access to many sources of information. To make a decision that maximizes benefits for any given consumer, that consumer would need to consider information including utility bills for at least a year (and have the ability to disaggregate the portion of the utility bill specific to the water heater), the expected lifetime of the product, knowledge of equipment and installation costs up front, knowledge of each potential product's efficiency and performance in the field, future repair and maintenance costs, the value of future operating savings and costs in the present year, *etc*. This is a time-consuming and nontrivial calculation for even the most motivated consumer and requires significant data collection to make even a decent approximation. While there is some information easily available to the consumer prior to making a purchase (*e.g.*, labels, technical specifications, price estimates, *etc.*), this information typically assumes an average household. Therefore, for a consumer wishing to make an informed decision that results in minimization of life-cycle costs in the no-new-standards case based on such a label, it would require knowing how their own situation differs from an average national household (*e.g.*, hot water usage, energy price, ambient indoor air temperature, inlet water temperature, *etc.*). This evaluation is very complex. These challenges are part of the reason why consumer perception of energy consumption of appliances is varied and the extent to which consumers choose product efficiency based on this perceived energy consumption is mixed, as discussed in some of the literature cited above. There is empirical evidence that, on average, consumers' perceived energy consumption of household appliances and equipment does not match the actual energy consumption.

Acknowledging this consumer behavior, PHCC commented that in the case of replacement due to a failed water heater, many consumers will prioritize a water heater that is readily available within their price range and will not consider energy efficiency in their decision. They further comment that most consumers never even look at the energy label, they just want hot water at the lowest cost. (PHCC, No. 1151 at p. 6)

As stated above, the use of a random assignment of water heater efficiency in the no-new-standards case of LCC model is a methodological approach that reflects the full range of consumer behaviors in this market, including consumers who make informed and economically beneficial decisions and other consumers who, due to the market failures discussed, do not or cannot make such perfectly economically beneficial decisions. The methodology is further constrained by shipments data by efficiency level; it must produce an overall distribution that matches the available data. In the simplest case, where baseline market shares are split between one lower efficiency level and one higher efficiency level, DOE's methodology results in the following groups of consumers:

(1) Consumers who, in the absence of standards, choose a lower efficiency product with a lower life-cycle cost based on their surveyed hot water usage. These consumers are making an optimal choice from the perspective of cost savings in the model in the no-new-standards case. With amended standards, they are made to purchase a more efficient product and therefore experience a net cost in the standards case. The efficiency assignment model is already assigning minimal-cost choices to this fraction of consumers in the no-new-standards case.

(2) Consumers who, in the absence of standards, choose a higher efficiency product that also lowers their life-cycle cost compared to the baseline efficiency product. These consumers are making a cost-minimizing choice in the model in the no-new-standards case. With amended standards, these consumers are not impacted because they are already purchasing a standards-

compliant product. The efficiency assignment model is already assigning minimal-cost choices to this fraction of consumers in the no-new-standards case.

(3) Consumers who, in the absence of standards, choose a lower efficiency product that does not minimize their life-cycle cost. The market failures discussed above apply to these consumers, preventing them from making the choice that minimizes their costs in the no-new-standards case. With amended standards, they are made to purchase a more efficient product that ultimately results in a lower life-cycle cost. These consumers experience a net benefit as a result of the standard.

(4) Consumers who, in the absence of standards, choose a higher efficiency product that does not lower their life-cycle cost compared to the baseline or lower efficiency product. Although these consumers are choosing a higher efficiency product in the no-new-standards case, they may have incomplete knowledge of the energy consumption of the equipment or may value environmental features such as efficiency more heavily, resulting in a choice of a higher efficiency product that does not lower life-cycle cost compared to a baseline or lower efficiency product. With amended standards, these consumers are not impacted because they are already purchasing a standards-compliant product.

DOE's methodological approach is a proxy that ultimately reflects a diversity of scenarios for consumers and therefore the range of outcomes that will result from this diversity. The approach already reflects market share outcomes consistent with some degree of market efficiency and optimal decision-making among some consumers, but the approach also acknowledges a number of factors that hinder perfect decision-making for others. Furthermore, the model produces an overall distribution of efficiency that matches the available shipments data.

Although DOE's random assignment methodology does not explicitly model consumer decision making, nor does it take a stance on the rationality or irrationality of specific consumers, DOE believes that the approach would be consistent with a model in which some share of consumers make economically optimal decisions, and some consumers—in the face of market failures—do not. The use of a random assignment of water heater efficiency is a methodological approach that reflects the full range of consumer behaviors in this market, including consumers who make economically beneficial decisions and consumers who, due to market failures, do not or cannot make such economically beneficial decisions, both of which occur in reality. Within those constraints, DOE then assigns product efficiencies to consumers in the LCC, consistent with the economics literature discussed above, to reflect neither purely rational nor purely irrational decision-making.

DOE's analytical approach reflects some degree of market efficiency. An alternative approach which assumes consumer behavior is based solely on cost outcomes, for example by ranking LCCs and using those to assign efficiencies as suggested by the commenters, is not evidenced by the scientific literature surveyed above or by any data submitted in the course of this rulemaking. Such an approach would depend on the assumption, for example, that homeowners know—as a rule—the efficiency of their homes' water heater and water heating energy use, such that they always make water heating investments accordingly. Similarly, such an approach would assume that, faced with a water heater failure, homeowners will always select as a replacement the most economically beneficial available model. Given the work documenting market failures in energy efficiency contexts described above, DOE believes that such assumptions would bias the outcome of the analysis to the least favorable results. DOE's approach, by contrast, recognizes that assumptions like these hold for some consumers some of the time—but not all consumers and not at all times.

As part of the random assignment, some households or buildings with large water heating loads will be assigned higher-efficiency water heaters in the no-new-standards case, and some households or buildings with particularly low water heating loads will be assigned baseline water heaters—i.e., the lowest cost investments.

DOE ran a sensitivity to look at the base-case shipment distribution in 2030 that would be expected if every consumer made their purchasing decision based on minimizing their life-cycle costs to understand how this compares to actual consumer purchases based on the data on shipments by efficiency. If every consumer in the LCC sample chose a product that minimized their total life-cycle cost (i.e., perfectly rational, cost-minimizing consumers), the resulting distribution of products by efficiency would deviate significantly from the actual efficiency distribution, as determined from market share data and shipments data by efficiency. For example, for medium ESWHs, the baseline efficiency (EL 0, representing an electric resistance water heater) results in a minimum life-cycle cost for only 36 percent of all consumers in the LCC analysis, while higher efficiency heat pump water heaters (ELs 1, 2, and 3) result in a minimum life-cycle cost for the remaining 64 percent of consumers. Therefore, in a scenario in which all consumers made cost-minimizing choices, one would expect the efficiency distribution of new shipments in 2030, without any amended standards, to be 36 percent electric resistance medium ESWHs and 64 percent heat pump medium ESWHs (at various efficiencies). However, the projected efficiency distribution in 2030, based on existing market share and actual shipments data (and even accounting for the recent growth trend of heat pump water heaters), is that only 12 percent of the market will be heat pump water heaters despite the fact that these water heaters would result in lower total life-cycle costs for 64 percent of consumers, i.e., at least half of consumers will be selecting a water heater that does not minimize their costs. This significant discrepancy suggests the presence of the market failures discussed previously in the medium ESWH market, which prevents a significant portion of consumers from making purchasing decisions that would minimize their life-cycle costs.

Regarding the role of contractors, DOE notes that they can exert a high degree of influence over the type of water heater purchased. DOE acknowledges that they can serve as an information mediator. However, it is possible for a contractor to also influence the decision toward a familiar like-for-like replacement, for example, or perhaps the quickest replacement option available (*e.g.*, based on equipment availability). An individual contractor may not be familiar with every product option available on the market. Ultimately, there are multiple actors involved in the decision-making process which results in complex purchasing behavior.

As DOE has noted, there is a complex set of behavioral factors, with sometimes opposing effects, affecting the water heater market. It is impractical to model every consumer decision incorporating all of these effects at this extreme level of granularity given the limited available data. Given these myriad factors, DOE estimates the resulting distribution of such a model would be very scattered with high variability. It is for this reason DOE utilizes a random distribution (after accounting for market share constraints) to approximate these effects. This is the standard methodological approach used on all of DOE's prior rules. The methodology is not an assertion of economic irrationality, but instead, it is a methodological approximation of complex consumer behavior. The analysis is neither necessarily biased toward high or low energy savings. The methodology does not preferentially assign lower-efficiency water heaters to households in the no-new-standards case where savings from the rule would be greatest, nor does it preferentially assign lower-efficiency water heaters to households in the no-new-standards case where savings from the rule would be smallest. However, it is worth noting that energy use could be improperly estimated if preferences for energy efficiency are correlated with demand for hot water. Some consumers were assigned the water heaters that they would have chosen if they had engaged in the kind of perfect economic thinking upon which the commenters have focused. Others were assigned less-efficient water heaters even where a more-efficient water heater would eventually result in life-cycle savings, simulating scenarios where, for example, various market failures prevent consumers from realizing those savings. Still others were assigned water heaters that were more efficient than one would expect simply from life-cycle costs analysis, reflecting, say, "green" behavior, whereby consumers ascribe independent value to minimizing harm to the environment.

DOE cites the available economic literature of which it is aware on this subject, supporting the existence of the various market failures in other appliance markets which would give rise to such a distribution, and has requested more data or studies on this topic in the May 2020 RFI, March 2022 preliminary analysis, and July 2023 NOPR. DOE is not aware of any specific study regarding how consumer water heaters (and their efficiency) are purchased.

In summary, DOE's efficiency assignment methodology produces overall results that are consistent with the observed distribution of efficiency across products as seen in the shipments data. The methodology also results in a share of consumers being assigned product efficiencies that minimize their lifetime costs in the absence of standards. This represents consumers making informed decisions regarding the efficiency of their products, without amended standards. These consumers will be negatively impacted by the adopted standard levels and the analysis accounts for these impacts. However, the methodology also acknowledges that some consumers are unable to minimize the life-cycle costs of their products for a variety of reasons discussed in the economics literature (*e.g.*, renters with no say in the products purchased for their household). Even for motivated and informed consumers, the information and data required to ultimately make the best product choice that minimizes life-cycle cost is complex and time-consuming. As a result, there are a subset of consumers for whom adopting more stringent standard levels will result in life-cycle savings. In contrast to some commenters' characterization, DOE's methodology already reflects some degree of market efficiency in terms of consumer choice of product efficiency, but it also reflects a variety of observed effects that inhibit perfect market efficiency. This is representative of the water heater market. On the whole, when accounting for both consumers negatively impacted by, as well as those benefiting from, amended standards, DOE's analysis demonstrates that there are economically justified savings.

Finally, DOE notes that the recommendations of the NAS report, which pertain to the processes by which DOE analyzes energy conservation standards, will be addressed as part of a separate notice-and-comment process.

9. Payback Period Analysis

The payback period is the amount of time (expressed in years) it takes the consumer to recover the additional installed cost of more-efficient products, compared to baseline products, through energy cost savings. Payback periods that exceed the life of the product mean that the increased total installed cost is not recovered in reduced operating expenses.

The inputs to the PBP calculation for each efficiency level are the change in total installed cost of the product and the change in the first-year annual operating expenditures relative to the baseline. DOE refers to this as a "simple PBP" because it does not consider changes over time in operating cost savings. The PBP calculation uses the same inputs as the LCC analysis when deriving first-year operating costs.

As noted previously, EPCA establishes a rebuttable presumption that a standard is economically justified if the Secretary finds that the additional cost to the consumer of purchasing a product complying with an energy conservation standard level will be less than three times the value of the first year's energy savings resulting from the standard, as calculated under the applicable test procedure. (42 U.S.C. 6295(o)(2)(B)(iii)) For each considered efficiency level, DOE determined the value of the first year's energy savings by calculating the energy savings in accordance with the applicable DOE test procedure, and multiplying those savings by the average energy price projection for the year in which compliance with the amended standards would be required.

Armada noted that the EPCA creates a rebuttable presumption that an energy conservation standard is economically justified if the additional cost is less than three times the value of the first year's energy savings, but the initial costs to switch from an electric resistance storage water heater to one with heat pump technology is greater than a three-year payback period, and that assumes the consumer's home can accommodate a heat pump water heater. (Armada, No. 1193 at pp. 5-6) In response, DOE notes that the rebuttable presumption provision is not a requirement that the average PBP of a standard must be less than three years. Rather, it establishes a presumption that a standard meeting that criteria is economically justified, which is then evaluated further using the other criteria used to evaluate economic justification. Whether the presumption is or is not met, a determination of economic justification must be based on the criteria specified by EPCA, as is the case for this final rule.

10. Accounting for Product Switching

For the preliminary analysis, DOE did not account for the product switching under potential standards. For the July 2023 NOPR and this final rule, DOE maintained the same approach and did not include any product switching in its analysis, other than consumers potentially downsizing their electric storage water heater to a small electric water heater, as discussed in more detail in section IV.G.1 of this document. DOE assumes that any product switching as a result of the proposed standards is likely to be minimal.

As discussed in the specific examples below, the costs to switch to another product class are higher than simply purchasing a standards-compliant product in the same product class. When faced with the need to replace a water heater, a consumer can either install a standards-compliant product of the same product class as they originally had, or spend even more to switch to an alternative product class. Because of this higher cost to switch, DOE concludes it is extremely unlikely that consumers would choose to spend more to switch product classes specifically in response to amended standards. In the absence of amended standards, some consumers choose to switch for reasons other than simply cost, and that is reflected in historical market trends that are incorporated into the analysis. However, for the purposes of the analysis, the issue is whether *more* consumers would switch due to the higher incremental costs of standards-compliant products. DOE concludes that this is very unlikely and therefore market trends will be unaffected.

In the hypothetical case of a consumer switching from a gas-fired storage water heater to an electric water heater (storage or instantaneous), there are likely additional installation costs necessary to add an electrical connection since both of these types of electric water heaters require high wattage. These are costs above and beyond the normal installation costs included in the LCC analysis. In some cases, it may be possible to install a 120-volt heat pump storage water heater with minimal additional installation costs, particularly if there is a standard electrical outlet nearby already. In most cases, however, a standard 240-volt electrical storage water heater would be installed. To do so, the consumer would need to add a 240-volt circuit to either an existing electrical panel or upgrade the entire panel if there is insufficient room for the additional amperage. The installation of a new 240-volt circuit by a qualified electrician will be at least several hundred dollars. Panel upgrade costs are significant and can be approximately $750 – $2,000 to upgrade to a 200-amp electrical panel.[125] Older homes and homes with gas-fired space heating (*e.g.*, homes with gas furnaces) are more likely to need an electrical panel upgrade in order to install an electric storage water heater, given the relatively modest electrical needs of the home at the time of construction. Given the significant additional installation costs for nearly all homes potentially switching to an electric water heater, DOE estimates that very few consumers would switch from gas-fired storage water heaters to electric water heaters as a result of an energy conservation standard, especially at the proposed standard at TSL 2. At TSL 2, the average total installed cost of an electric storage water heater is $1,855 compared to the average total installed cost of $1,578 for a gas-fired storage water heater (see section V.B.1). Further, these costs do not include the electrical upgrade costs necessary when switching from a gas-fired to an electric water heater. When including those costs, the average total installed cost to switch to an electric water heater is significantly higher than the standards-compliant gas-fired storage water heater (electric instantaneous water heaters were not analyzed in this rule, however the electrical panel upgrade cost alone is nearly as much as a standards-

[125] For example, see: www.homeadvisor.com/cost/electrical/upgrade-an-electrical-panel/#upgrade (last accessed Dec. 1, 2023).

compliant gas-fired storage water heater). Switching from a gas-fired to an electrical water heater is especially unlikely in the case of an emergency replacement where time is a critical factor. When a water heater fails, consumers typically have limited time to make a decision on which new water heater the consumer is going to choose to purchase and rely upon replacing the water heater with one that is similar to the one that failed. Consumers are unlikely to invest in switching fuels to a water heater that utilizes a different fuel source in the emergency replacement scenario.

In the hypothetical case of a consumer switching from an electric storage water heater to a gas-fired water heater, there are, similarly, additional installation costs necessary to add a gas connection. Based on RECS 2020, DOE estimates that only 25 percent of homes with an electric storage water heater currently use natural gas and an additional 25 percent reported that natural gas is available in the neighborhood. Therefore, the option to switch to a gas-fired water heater is not available to half of consumers and for another 25 percent, it would require bringing in a natural gas connection from the street level to the home. Additionally, switching to a gas-fired water heater would require the installation of new gas plumbing in the home, even if the home currently uses natural gas, which would add several hundreds of dollars to the installation costs.[126] An additional 10 percent of homes use LPG, but the fuel costs are much more expensive than natural gas and requires significant gas line connection upgrades to connect the LPG tank to the water heater. Even in homes with an existing gas connection, new venting would need to be installed for either gas-fired storage water

[126] For example, see: www.homeadvisor.com/cost/plumbing/install-or-repair-gas-pipes/ (last accessed March 8, 2024).

heaters or gas-fired instantaneous water heaters. Installing new venting represents a significant additional cost when switching from an electric water heater to a gas fired heater. The LCC averages presented in V.B.1 for the gas-fired water heaters include some situations where vent replacement is not necessary, and none of the replacement situations require adding gas lines, therefore typical installation costs for switching from an electric water heater to a gas-fired water heater would be higher than the averages presented in section V.B.1. Therefore, the total installed costs for either gas-fired option, including all the necessary venting and additional gas lines in the home, are larger than replacing the electrical storage water heater with a standards-compliant model (at the proposed level). As a result, DOE estimates that very few consumers would switch from electric storage water heaters to gas-fired water heaters as a result of an energy conservation standard, particularly in the case of an emergency replacement.

Even if some consumers of medium ESWHs elected to switch to a non-electric water heater (e.g., a GSWH), despite the additional costs of doing so and instead of simply purchasing a standards-compliant medium ESWH, the rule would still save a significant amount of energy. These consumers would still need to purchase a standards-compliant GSWH. Such switching from medium ESWHs to GSWHs or GIWHs would result in a slight increase in FFC energy consumption for these consumers, however that is more than made up for by the rest of the savings from medium ESWH consumers, even after accounting for consumers switching to small ESWHs. The energy savings for the rest of the medium ESWHs are at least an order of magnitude larger than any incremental increase in energy consumption from a small subset of consumers who might switch to GSWHs or GIWHs. Under the assumption that all such consumers who switch to gas-fired water heaters face an increase in cost, the total percentage of existing medium ESWH consumers experiencing a net cost as a result of the rule would therefore increase by a proportional amount. For example, even if 10 percent of medium ESWH consumers elected to switch to gas-fired water heaters despite the costs, the percentage of consumers experiencing a net cost would increase by at most 10 percent and the average LCC savings for medium ESWH consumers would still be positive, which would not change DOE's conclusion that the standards adopted are economically justified.

Lastly, in the hypothetical case of a consumer switching from a GSWH to a GIWH, there are additional installation costs necessary as well. The vast majority of GSWHs utilize non-condensing technology that utilizes Category I type B metal vent material, whereas switching to GIWHs would require Category III or Category IV venting material. Regarding non-condensing GIWHs, A.O. Smith noted that these utilize Category III venting (A.O. Smith, No. 1182 at p. 15). Condensing GIWHs require Category IV venting. Switching from a GSWH to a GIWH would therefore require replacing the venting in either case. Replacing the venting system would result in significant installation costs. Additionally, given the significantly higher Btu/h input required for instantaneous water heaters, it may be necessary to upgrade the gas line feeding the water heater to a larger diameter when switching from GSWH to GIWH. This is especially true if the line also services a gas furnace. Upgrading a gas line could add several hundred dollars in extra costs or more. As a result of all the cost considerations above, DOE estimates that very few consumers would switch from GSWHs to GIWHs specifically as a result of the incremental costs of the amended energy conservation standard for GSWH, particularly in the case of an emergency replacement.

Ravnitzky expressed concern that the proposed standards favor heat pump water heaters over gas-fired or electric resistance water heaters. Ravnitzky claimed that the proposed standards would result in non-heat pump water heaters becoming more expensive and less competitive in the market and may force some consumers to switch to heat pump water heaters.[127] (Ravnitzky, No. 73 at p. 1)

In response, given the upfront cost differential for heat pump electric storage water heaters and gas-fired water storage heaters, DOE does not expect that the adopted standards would induce consumers to switch to heat pump water heaters. In addition, DOE notes that gas-fired storage water heaters are not being eliminated as a result of the standards being established in this final rule.

According to NPGA, APGA, AGA, and Rinnai, DOE made an assumption about product switching, then reinforced its assumption without analysis, ignoring the possibility that consumers may want to switch product classes based on the proposed rule, but product classes may not be available for such switching, and based on this assumption, DOE conveniently omitted any installation costs in its LCC and PBP analysis, showing its market analysis is inherently flawed and must be reevaluated. (NPGA, APGA, AGA, and Rinnai, No. 441 at p. 4-5) DOE notes that its assessment is based on the comparison of total installed costs needed to switch from product class to product class. In response, DOE determined that there would be minimal switching due to the additional installation cost for a variety of possible scenarios, as discussed above.

[127] Ravnitsky incorrectly asserted that the proposed standards would require a minimum UEF of 0.96 for gas-fired water heaters, 0.95 for electric resistance water heaters, and 0.85 for heat pump water heaters.

Specifically in the case of switching from a GSWH to a GIWH, these costs include upgrading gas lines and replacing the venting. Like-for-like replacement for the water heater product classes considered in this rulemaking, as DOE determined and summarized in the installation cost analysis, is the most cost efficient. DOE does not reject the idea that consumers may choose a different product class in response to the no new standards case for reasons other than just total costs. Indeed, the shipments projection accounts for recent market trends that show growing consumer demand for GIWHs compared to GSWHs.

NMHC and NAA stated that DOE's assumption of minimal product switching as a result of the proposed standard fails to account for forced product switching driven by typical space limitations in existing multifamily dwellings where frequently the water heater shares a small closet with stacked laundry facilities and owners will be forced to switch to instantaneous water heaters with additional installation costs associated with venting, larger-sized gas supply piping, or electrical panel upsizing. (NMHC and NAA, No. 996 at p. 5) In response, DOE notes that existing market trends are incorporated into the shipments analysis and projection. To the extent that some product classes are becoming more prevalent in certain types of buildings, that is reflected in the no-new-standards case shipments projection. The most commonly used electric water heater for the scenario described by NMHC and NAA would be a low-boy electric storage water heater, likely to be in the small ESWH product class. This rule does not amend standards for small ESWHs and therefore the consumers of this product class will not be impacted. As DOE has discussed above, the costs to switch product classes in response to amended standards are larger than simply purchasing standards-compliant products within the same product classes. Therefore DOE estimates that no additional switching will occur beyond existing market trends.

NRECA stated that a large percentage of co-op consumers have no access to natural gas service and have no affordable alternative option for a product that performs equivalent to electric resistance water heating, and therefore eliminating electric resistance water heating as an option in the market would pose a serious problem for many of the consumer-members served by cooperatives. They commented that these consumers that could not afford heat pump water heaters or their housing stock does not allow for their installation may be forced to choose electric tankless (or instantaneous) water heaters, which units may provide good comfort to consumers but have negative impacts to utilities by potentially creating spikes in demand of 20 kW instantaneously. NRECA commented that adding to a cooperative's peak demand can significantly raise their costs and add to the electric rates of all their consumer-members who must bear the cost. NRECA stated that at least one cooperative told them that most new housing stock in their territory is being equipped with electric tankless units and that it is not clear that DOE's analysis accounts for switching from electric storage to instantaneous electric. (NRECA, No. 1127 at p. 9) In response, DOE reiterates that a significant cost adder has been applied to the fraction of electric storage consumers that have challenging installation cases. For these consumers, DOE considered several downsizing options with significantly lower installation costs, including switching to a small electric storage water heater, and took that impact into account in its shipment analysis (see section IV.G.1.a). In regards to the grid impact, this is discussed more in section III.A.3. Finally, DOE notes that although it did not analyze electric instantaneous water heaters, they represent a very small market share at present. DOE did include, however, an option to pair a small electric storage water heater with a "booster" instantaneous water heater as one of the switching options for medium electric storage water heaters (see section IV.G.1.a).

Atmos Energy argued that because the cost to fuel switch is high, DOE fails to "acknowledge the equally prohibitive costs that will be associated with high efficiency gas appliances as a result of this proposal and the lack of gas-fired replacements in the market." (Atmos Energy, No. 1183 at p. 6). Rinnai argued that DOE has failed to take into account substitution effects in replacement markets. Rinnai stated that the following are lacking from the analysis: replacement of water heaters with same category of consumer water heaters that meet a particular standard level; replacement with water heaters using different fuel or different product category (*e.g.*, GSWH to GIWH; GSWH to ESWH; ESWH to GSWH, *etc.*); and repair of existing product; thereby delaying the replacement. (Rinnai, No. 1186 at pp. 30-31) The Gas Association Commenters commented that the proposals in the July 2023 NOPR would create an enhanced market for heat pumps, diminishing competition between gas and electric water heaters. (Gas Association Commenters, No. 1181 at pp. 32–39) A.O. Smith stated that storage and tankless water heaters use incompatible venting systems (GSWH use Cat I while non-condensing tankless water heaters use Cat III). (A.O. Smith, No. 1182 at p. 15) As discussed above, DOE estimates that switching between gas-fired and electric water heaters as a result of the rule is likely to be negligible, as is switching from gas-fired storage to instantaneous water heaters, due to the high installation costs of such switching, (costs that are acknowledged to be high by Atmos Energy in their comment).

DOE finds no evidence that there would be a lack of gas-fired water heater models available in the standards case for replacements. Many such models are currently available by multiple manufacturers. DOE acknowledges that in the standards case, many electric water heaters would transition to heat pump water heaters. However, since DOE estimates negligible switching between electric and gas-fired water heaters, there is no reason to expect this would alter the competition between electric and gas-fired water heater markets. Furthermore, many manufacturers produce both electric and gas-fired water heaters. Lastly, DOE agrees that gas-fired storage and instantaneous water heaters use incompatible venting systems and therefore switching from storage to instantaneous would require significant extra installation costs. See chapter 8 and appendix 8D of the final rule TSD for detailed description of the installation costs.

Noritz commented that the ability to replace a water heater in an emergency is an important attribute of value to consumers, and changes in installation patterns raise costs and impose other time-related constraints such as changing venting patterns, carpentry to make changes to the house, and possible electrical work to complete installation. (Noritz, No. 1202 at pp. 1-2) PHCC commented that in the case of replacement due to a failed water heater, many consumers will prioritize a water heater that is readily available within their price range and will not consider energy efficiency in their decision. According to PHCC, energy efficiency increases costs and decreases demand which leads to a longer wait time for installation and makes a more energy efficient water heater an unattractive option in a time when households simply care about having hot water and a working water heater as soon as possible. (PHCC, No. 1151 at p. 6) DOE agrees that in emergency replacement, like-for-like equipment provides the most convenience to the consumer. However, DOE estimates that the installation of condensing equipment, including the flue venting, the condensate pump, and neutralizer can be accomplished as part of an emergency replacement, meaning that for emergency replacements, non-condensing equipment do not bring significant additional value.

11. Analytical Results

AHRI commented that DOE does not provide a measure of uncertainty in LCC results. AHRI commented that each independent variable in LCC analysis has uncertainty, and DOE does not document how confident DOE should be in its estimates. AHRI asked DOE the following questions related to model uncertainty: What is the estimated standard deviation around the mean change in LCC at each EL and for each product class? (AHRI, No. 1167 at p. 23) AHRI commented that DOE does not take account of the fact that operating costs, including energy, are deductible as business expenses for Federal and some state income taxes for commercial customers in its LCC analysis and asks for DOE's justification for not taking it into account. AHRI recommended that DOE considers the effects of this tax deductibility in computing the change in life cycle cost. AHRI claimed that failing to account for this is inconsistent with other aspects of DOE's analyses. (AHRI, No. 1167 at p. 16)

In response, DOE clarifies that it uses probability distributions for a number of input variables that are reasonably expected to exhibit natural variation and diversity in practice (*e.g.*, lifetime, repair cost, installation costs). These probability distributions are modeling diversity. In contrast, DOE addresses input uncertainty primarily with the use of sensitivity scenarios. To determine whether the conclusions of the analysis are robust, DOE performed several sensitivity scenarios with more extreme versions of these input variables (*e.g.*, high/low economic growth and energy price scenarios, alternative price trend scenarios, alternative mean lifetime scenarios). The relative comparison of potential standard levels in the analysis remains the same throughout these sensitivity scenarios, confirming that the conclusion of economic justification is robust despite some input uncertainty. Furthermore, DOE provides a range of statistics in the LCC spreadsheet, including median values and values at various percentiles for many intermediate variables, as well as the full data output table for all 10,000 samples. For example, the 25th and 75th percentiles of average LCC savings for all ELs for all product classes are available in the LCC spreadsheet. DOE also provides a distribution of impacts, including consumers with a net benefit, net cost, and not impacted by the rule in the LCC spreadsheet and in chapter 8 of the final rule TSD.

DOE develops probabilities for as many inputs to the LCC analysis as possible, to reflect the distribution of impacts as comprehensively as possible. For example, DOE develops probabilities for building sampling, installation costs, lifetime, discount rate, and efficiency distribution, among other inputs. If there are insufficient data with respect to a specific input parameter to create a robust probability distribution, DOE will utilize a single input parameter. Such approach is neither arbitrary nor capricious; it is informed by the available data.

The installation cost estimates are the result of a significant research and cite multiple sources, as discussed at length in section IV.F.2 and appendix 8D of the final rule TSD. DOE has incorporated feedback from various stakeholders and revised those costs for this final rule.

Regarding deductible business expenses, DOE notes that equipment purchases would also be deductible, and that increased equipment expenses and lower operating expenses would have opposing effects on total deductions. Even if overall deductions were to decrease as a result of the rule, those savings could be easily invested in other parts of the business in order to have no net impact on a business' tax burden. Furthermore, DOE notes that the estimation of commercial discount rates accounts for the tax deductibility of the energy costs and capital investment depreciation and therefore the net present value of the future operating cost savings in the LCC analysis should already reflect that effect.

DOE provides stakeholders with the opportunity to provide accurate data to represent a breadth of operating conditions, prices, and use cases. In the absence of stakeholder provided information, DOE makes a good-faith effort to collect reliable data from various sources and summarize assumptions on the missing parameters. The Monte Carlo simulation and its large number of samples (10,000 for each product class) ensures that the results converge to a representative average. For some inputs whose uncertainty is not well characterized, such as future equipment prices or economic growth conditions, DOE performed a series of sensitivity analyses to ensure that the results of the analysis are not strongly dependent on those inputs and that the conclusions of the analysis remain the same. As a result, DOE's conclusion of economic justification is robust to a broad range of sensitivity scenarios which capture the uncertainty inherent in economic projections.

DOE acknowledges that in the LCC, there may be a handful of outcomes with large benefits or costs. Large outlier LCC savings, both positive and negative, may affect the average of LCC savings across the whole sample of impacted consumers. In particular, for medium ESWHs, there are some outcomes with LCC savings that are over 10 times the average across the whole sample. Therefore, for medium ESWHs, DOE considered an additional sensitivity analysis that eliminated these outcomes with large benefits. Specifically, DOE removed outcomes with positive LCC savings that exceed the absolute magnitude of the largest LCC costs, so that the final distribution of outcomes is bounded by similar extremes (positive and negative). This sensitivity removes 245 outcomes out of 8,801 impacted consumers. The resulting average LCC savings in the sensitivity analysis are reduced to $581, compared to $859 in the reference case. Although the average LCC savings are reduced in this sensitivity analysis, they remain positive and there continue to be significant energy and environmental savings. DOE continues to conclude that the adopted standard level for medium ESWHs is economically justified even in this sensitivity analysis that eliminates large positive results.

DOE further notes that such cases in the LCC, represented with outcomes resulting in large benefits or large costs, are likely to occur in the real-world as a reflection of the variability in the household characteristics across the United States. For example, a household with high usage (e.g., 5 plus occupants with frequent showering) located in an area with higher than average electricity rates, with lower than average installation costs (e.g., there is sufficient electrical, drainage, and space to accommodate the heat pump water heater) will result in that household seeing net benefits greater than the average population. Such a scenario is reflected in the model as a high-benefits case. While DOE conducted the sensitivity to test its conclusion that the standards adopted are economically justified even with conservative assumptions, DOE also believes that such high benefits or high costs cases reflect the realities of household characteristics across the United States.

G. Shipments Analysis

DOE uses projections of annual product shipments to calculate the national impacts of potential amended or new energy conservation standards on energy use, NPV, and future manufacturer cash flows.[128] The shipments model takes an accounting approach, tracking market shares of each product class and the vintage of units in the stock. Stock accounting uses product shipments as inputs to estimate the age distribution of in-service product stocks for all years. The age distribution of in-service product stocks is a key input to calculations of both the NES and NPV, because operating costs for any year depend on the age distribution of the stock.

DOE developed shipment projections based on historical data and an analysis of key market drivers for each product. DOE estimated consumer water heater shipments by projecting shipments in three market segments: (1) replacement of existing consumer water heaters; (2) new housing; and (3) new owners in buildings that did not previously have a consumer water heater or existing water heater owners that are adding an additional consumer water heater.[129]

[128] DOE uses data on manufacturer shipments as a proxy for national sales, as aggregate data on sales are lacking. In general, one would expect a close correspondence between shipments and sales.
[129] The new owners primarily consist of households that add or switch to a different water heater option during a major remodel. Because DOE calculates new owners as the residual between its shipments model compared to historical shipments, new owners also include shipments that switch away from water heater product class to another.

To project water heater replacement shipments, DOE developed retirement functions from water heater lifetime estimates and applied them to the existing products in the housing stock, which are tracked by vintage. DOE calculated replacement shipments using historical shipments and lifetime estimates. Annual historical shipments sources are: (1) Appliance Magazine;[130] (2) the Air-Conditioning, Heating, and Refrigeration Institute ("AHRI") website;[131] (3) multiple AHRI data submittals;[132] (4) the BRG Building Solutions 2022 report; (5) ENERGY STAR unit shipments data;[133] (6) Oil Heating Magazine;[134] and the 2010 Heating Products Final Rule. In addition, DOE adjusted replacement shipments by taking into account demolitions, using the estimated changes to the housing stock from *AEO2023*.

To project shipments to the new housing market, DOE used the *AEO2023* housing starts and commercial building floor space projections to estimate future numbers of new homes and commercial building floor space. DOE then used data from U.S. Census Characteristics of New Housing, [135,136] Home Innovation Research Labs

[130] Appliance Magazine. *Appliance Historical Statistical Review: 1954-2012*. 2014. UBM Canon.
[131] Air-Conditioning, Heating, and Refrigeration Institute. Water Heaters Historical Data. Available at: *www.ahrinet.org/resources/statistics/historical-data/residential-storage-water-heaters-historical-data* (last accessed Dec. 1, 2023).
[132] AHRI. Confidential Instantaneous Gas-fired Water Heater Shipments Data from 2004-2007 to LBNL. March 3, 2008; AHRI. Oil-fired Storage Water Heater (30/32 gallons) Shipments Data provided to DOE. 2008.
[133] ENERGY STAR. Unit Shipments data 2010-2021. multiple reports. Available at *www.energystar.gov/partner_resources/products_partner_resources/brand_owner_resources/unit_shipment_data* (last accessed Dec. 1, 2023).
[134] Oil Heating Magazine. Merchandising News: Monthly Data on Water Heaters Installed by Dealers 1997-2007. 2007.
[135] U.S. Census. Characteristics of New Housing from 1999-2022. Available at *www.census.gov/construction/chars/* (last accessed Dec. 1, 2023).
[136] U.S. Census. Characteristics of New Housing (Multi-Family Units) from 1973-2022. Available at *www.census.gov/construction/chars/mfu.html* (last accessed Dec. 1, 2023).

Annual Builder Practices Survey, [137] RECS 2020, AHS 2021, and CBECS 2018 to estimate new construction water heater saturations by consumer water heater product class.[138]

DOE estimated shipments to the new owners' market based on residual shipments from the calculated replacement and new construction shipments compared to historical shipments in the last 5 years (2018–2023 for this NOPR). DOE compared this with data from the Decision Analysts' 2002 to 2022 American Home Comfort Study[139] and 2022 BRG data, which showed similar historical fractions of new owners. DOE assumed that the new owner fraction in 2030 would be equal to the 10-year average of the historical data (2013–2022) and then decrease to zero by the end of the analysis period (2059). If the resulting fraction of new owners is negative, DOE assumed that it was primarily due to equipment switching or non-replacement and added this number to replacements (thus reducing the replacements value).

For the preliminary analysis and NOPR, assumptions regarding future policies encouraging electrification of households and electric water heating were speculative at that time, so such policies were not incorporated into the shipments projection.

[137] Home Innovation Research Labs (independent subsidiary of the National Association of Home Builders ("NAHB"). Annual Builder Practices Survey (2015-2019). Available at *www.homeinnovation.com/trends_and_reports/data/new_construction* (last accessed Dec. 1, 2023).
[138] Note that DOE does not project housing regionally. New housing is therefore assumed to grow in the same regional distribution as the current data would suggest.
[139] Decision Analysts, 2002, 2004, 2006, 2008, 2010, 2013, 2016, 2019, and 2022 American Home Comfort Study. Available at *www.decisionanalyst.com/Syndicated/HomeComfort/* (last accessed Dec. 1, 2023).

DOE acknowledges, however, that ongoing electrification policies at the Federal, State, and local levels are likely to encourage installation of electric water heaters in new homes and adoption of electric water heaters in homes that currently use gas-fired water heaters. For example, the Inflation Reduction Act includes incentives for heat pump water heaters and electrical panel upgrades. However, there are many uncertainties about the timing and impact of these policies that make it difficult to fully account for their likely impact on gas and electric water heater market shares in the time frame for this analysis (*i.e.*, 2030 through 2059). Nonetheless, DOE's shipments projections account for impacts that are most likely in the relevant time frame. The assumptions are described in chapter 9 and appendix 9A of the final rule TSD. The changes result in a decrease in gas-fired storage water heater shipments in the no-new-standards case in 2030 compared to the preliminary analysis. DOE acknowledges that electrification policies may result in a larger decrease in shipments of gas-fired water heaters than projected in this final rule, especially if stronger policies are adopted in coming years. However, this would occur in the no-new amended standards case and thus would only reduce the energy savings estimated in this adopted rule. For example, if incentives and rebates shifted 5 percent of shipments in the no-new amended standards case from gas-fired storage water heaters to heat pump electric storage water heaters, then the energy savings estimated for gas-fired storage water heaters in this adopted rule would decline by approximately 5 percent. The estimated consumer impacts are likely to be similar, however, except that the percentage of consumers with no impact at a given efficiency level would increase. DOE notes that the economic justification for the adopted rule would not change if DOE included the impact of incentives and rebates in the no-new-standards case, even if the absolute magnitude of the savings were to decline.

Gas Association Commenters advised that DOE should use State-level data rather than national data with differentiation between new and replacement market shares for each efficiency level in its analysis. Gas Association Commenters included specifics that they believe support this approach. (Gas Association Commenters, No. 1181 at pp. 35-37)

DOE has taken into account differences between new and replacement market throughout its shipments analysis. DOE does not have detailed State-level data and so did not consider it in its analysis.

GAAS commented that the shipment analysis should include historical and projections of shipments for water heaters broken down by end use applications and replacement versus new construction values. GAAS stated this would show that high efficiency options are gaining in market share without the need for more stringent energy efficiency standards. GAAS also commented that the Inflation Reduction Act ("IRA") projections should be included in electric water heater sale projections. (GAAS, No. 1139 at p. 7)

DOE's shipments analysis has considered historical and projected shipments disaggregated by applications and by replacement vs. new constructions markets using available data. Further details are available in chapter 9 and appendix 9A of the final rule TSD. DOE has accounted for recent trends in the adoption of high efficiency products in its analysis, including the impacts of recent policies incentivizing higher efficiency products in some jurisdictions.

BWC asked for further clarification on what measures were taken by DOE to ensure that product shipments that may have been recorded in several of the referenced sources in section IV.G were not accounted for multiple times, thus skewing the results of the data. (BWC, No. 1164 at p. 22)

DOE carefully evaluated each data source and then cross-checked against multiple available data sources. DOE validated its estimates to avoid double-counting. Chapter 9 and appendix 9A provide a description of how data sources were utilized in the shipments analysis. In summary, some data sources provided an overview of the overall market (*e.g.*, BRG data) whereas other data sources focused on a narrower subset (*e.g.*, ENERGY STAR shipments) by efficiency level, capacity, or other characteristic. All of these data sources complement each other.

BWC disagreed with DOE's estimate that heat pump water heaters currently account for approximately 8 percent of current sales in the United States. (BWC No. 1164 at p. 14) BWC disagreed with DOE's assumption that small electric storage water heaters make up 11 percent of the total market for electric storage water heaters with capacities ranging from 20 to 55 gallons and expressed that the actual figure is much higher. BWC commented that it is prepared to discuss the basis for this belief in a confidential conversation with DOE. (BWC, No. 1164 at p. 15)

DOE derived its estimates based on available data sources of historical shipments and markets shares as discussed in further detail in chapter 9 and appendix 9A. DOE clarifies that its estimate of small electric storage water heaters are specifically for those that meet the definition of the small electric storage water heater product class, based on the distribution of capacities and first-hour ratings available in the data sources and model databases. Some smaller capacity storage water heaters may not meet the definition of small electric storage water heaters. DOE also clarifies that its estimate of market shares at various efficiency levels (including heat pump water heaters), based on the data sources discussed in chapter 8 and appendix 8I, are presented for the first year of compliance (2030) and account for any recent historical trends. By 2030, DOE estimates that the heat pump water heater market share of the electric storage water heater market will exceed 10 percent.

EEI commented that DOE projects electric storage water heater (20–55 gallons except small electric storage water heaters) shipments dropping by well over 30 percent in the first year and never recovering compared to the "no new standards" case under the proposed rule, and this type of demand destruction could lead manufacturers to invest in and increase production of other less-efficient products. (EEI, No. 1198 at p. 4)

DOE acknowledges that some consumers may opt to change products, from electric storage water heaters to small electric storage water heaters, in response to the standard. This market dynamic is discussed in more detail in section IV.G.1.a below. Although DOE estimates that approximately 30 percent of electric storage water heater shipments will shift to small electric storage water heaters in the amended-standards case, this is not demand destruction as the commenter as characterized. This is a shift in consumer demand to an alternate product that is currently available. DOE acknowledges that that this shift will result in lower energy savings than if no consumers switched products, and this is accounted for in the analyses. DOE further notes that at the adopted standard level, the minimum efficiency requirement for small electric storage water heaters is still achievable with electric resistance heating technology; therefore, for this product class, manufacturers will continue to produce similar water heaters to those that are produced today. While there will be an increase in production for small electric water heaters to meet this increased demand, there will also be an increase in the production of efficient water heaters to meet the demand of the rest of the electric storage water heater market.

1. Impact of Potential Standards on Shipments

a. Impact of Consumer Choice for Electric Storage Water Heaters

DOE applied a consumer choice model to estimate the impact on electric storage water heaters shipments in the case of a heat pump water heater standard. As noted previously (*see* section IV.F.10), DOE did not include other product switching (*e.g.*, using different fuels) in its analysis as this is likely to be a minimal effect. This is especially true in the case of an emergency replacement.

DOE accounted for the potential of consumers selecting one or more smaller electric storage water heaters with or without a "booster" instantaneous water heater instead of replacing a larger electric storage water heater with a heat pump water heater.[140] DOE analyzed two main scenarios for a heat pump standard: 1) When electric storage water heaters ≥ 20 gal and ≤ 55 gal, excluding small ESWHs, could potentially

[140] *See* Rheem's booster instantaneous water heater, which can increase the availability of hot water for storage tank water heaters at *www.rheem.com/innovations/innovation_residential/water-heater-booster/*.

downsize to the small electric storage water heater product class, due to a heat pump standard to electric storage water heaters ≥ 20 gal and ≤ 55 gal, excluding small ESWHs only; and 2) A heat pump water heater standard for all ESWH product classes, where ESWHs could potentially downsize to very small water heaters. DOE identified households from the electric consumer water heater sample that might downsize at each of the considered standard levels based on water heater sizing criteria and matching to the different consumer choice options that would result in no loss of utility. DOE assigned an effective storage volume and draw pattern to sampled consumer water heaters based on data from RECS 2020 and CBECS 2018. DOE selected the households or buildings that would downsize based on the fact that the consumer would have a financial incentive to downsize in the short term (*e.g.*, lower first cost), even though in some cases downsizing might not be advantageous in the long run compared to installing a heat pump water heater. Table IV.27 and Table IV.28 show the resulting estimated shipment market share impacted for each scenario. Additional details of this analysis can be found in chapter 9 and appendix 8D of the TSD.

Table IV.27 Consumer Choice Results for Electric Storage Water Heaters (Assuming Heat Pump Standard for Electric Storage Water Heaters, ≥ 20 gal and ≤ 55 gal, excluding Small ESWHs Only)

Consumer Choice Options	Efficiency Level, Market Share Impacted (%)			
	0	1	2	3
Not Switching	100%	70%	70%	70%
Small ESWH	0%	15%	15%	15%
Small ESWH + Booster	0%	9%	9%	9%
Two Small ESWH	0%	5%	5%	5%

Table IV.28 Consumer Choice Results for Electric Storage Water Heaters (Assuming Heat Pump Standard for all Electric Storage Water Heater Product Classes)

Consumer Choice Options	Efficiency Level, Market Share Impacted (%)			
	0	1	2	3
Small Electric Storage Water Heaters, ≥ 20 gal and ≤ 35 gal and FHR < 51 gal				
Not Switching	100%	6%		
Very Small ESWH + One Booster	0%	90%		
Two Very Small ESWH	0%	3%		
Two Very Small ESWH + One Booster	0%	0%		
Electric Storage Water Heaters, ≥ 20 gal and ≤ 55 gal, excluding Small ESWHs				
Not Switching	100%	82%	83%	81%
Very Small ESWH + One Booster	0%	9%	9%	9%
Two Very Small ESWH	0%	6%	6%	6%
Two Very Small ESWH + One Booster	0%	3%	3%	4%

The shipments model considers the switching that might occur in each year of the analysis period (2030–2059). To do so, DOE estimated the switching in the first year of the analysis period (2030), using data on willingness to pay, in the LCC analysis and derived trends from 2030 to 2059. The shipments model also tracks the number of additional consumer water heaters shipped in each year. *See* appendix 9A of this final rule TSD for further details regarding how DOE estimated switching between various electric water heater options.

BWC commented that the findings presented in appendix 9A of the July 2023 NOPR TSD do not align with its understanding of what has occurred in the residential water heater market since the most recent rulemaking on these products took effect in 2015. BWC also questioned how DOE could have accounted for grid-enabled water heater shipments in this appendix when the BRG report, referenced as the source for this appendix's findings, does not account for shipments of these types of products. For these reasons, BWC would welcome an opportunity to discuss this matter further confidentially with DOE. (BWC, No. 1164 at p. 22)

DOE derived its estimates based on multiple available data sources and shipments model. The BRG report is only one data source. Other sources include AHRI shipments data available online, shipments data submitted confidentially to DOE, shipment estimates from ENERGY STAR, EIA's Annual Electric Power Industry Report, and estimates from trade magazines, as discussed in chapter 9. DOE used the combination of all these data to estimate shipments of the smaller product classes, such as electric storage water heaters greater than 55 gallons. DOE also clarifies that it did not propose or adopt standards for grid-enabled water heaters and therefore they were not specifically considered in the analysis.

BWC recommended that DOE utilize information that is specific to the residential water heater market in supporting its claims relative to consumer preferences. In the absence of such information, BWC asked that DOE take a proactive approach by working directly with manufacturers, trade associations, consumer advocates, and other knowledgeable stakeholders to collect information that is timely and relevant to the products that are subject to this rulemaking through confidential interviews and disaggregated surveys. (BWC, No. 1164 at p. 24)

DOE has considered available information and data sources, including interviews with manufacturers, industry market research reports, confidentially submitted data, and feedback from an industry consultant. There are, however, no specific data or studies on consumer decision-making preferences that DOE is aware of, specifically with respect to the water heater market, other than what is revealed by shipments data and the market share of various products currently available. DOE derived its estimates of efficiency distributions based on these market data. Regarding DOE's estimates of consumer preferences and market failures, these are based on a wide body of economics literature as discussed in more detail in section IV.F.8.

b. Impact of Repair vs. Replace

DOE estimated a fraction of consumer water heater replacement installations that choose to repair their equipment, rather than replace their equipment in the new standards case. The approach captures not only a decrease in consumer water heater replacement shipments, but also the energy use from continuing to use the existing consumer water heater and the cost of the repair. DOE assumes that the demand for water heating is inelastic and, therefore, that no household or commercial building will forgo either repairing or replacing their equipment (either with a new consumer water heater or a suitable water heating alternative).

For details on DOE's shipments analysis, consumer choice, and the repair option, *see* chapter 9 of the final rule TSD.

H. National Impact Analysis

The NIA assesses the national energy savings ("NES") and the NPV from a national perspective of total consumer costs and savings that would be expected to result from new or amended standards at specific efficiency levels.[141] ("Consumer" in this context refers to consumers of the product being regulated.) DOE calculates the NES and NPV for the potential standard levels considered based on projections of annual product shipments, along with the annual energy consumption and total installed cost data from

[141] The NIA accounts for impacts in the United States and U.S. territories.

the energy use and LCC analyses. For the present analysis, DOE projected the energy savings, operating cost savings, product costs, and NPV of consumer benefits over the lifetime of consumer water heaters sold from 2030 through 2059.

DOE evaluates the impacts of new or amended standards by comparing a case without such standards with standards-case projections. The no-new-standards case characterizes energy use and consumer costs for each product class in the absence of new or amended energy conservation standards. For this projection, DOE considers historical trends in efficiency and various forces that are likely to affect the mix of efficiencies over time. DOE compares the no-new-standards case with projections characterizing the market for each product class if DOE adopted new or amended standards at specific energy efficiency levels (*i.e.*, the TSLs or standards cases) for that class. For the standards cases, DOE considers how a given standard would likely affect the market shares of products with efficiencies greater than the standard.

DOE uses a spreadsheet model to calculate the energy savings and the national consumer costs and savings from each TSL. Interested parties can review DOE's analyses by changing various input quantities within the spreadsheet. The NIA spreadsheet model uses typical values (as opposed to probability distributions) as inputs.

Table IV.29 summarizes the inputs and methods DOE used for the NIA analysis for the final rule. Discussion of these inputs and methods follows the table. *See* chapter 10 of the final rule TSD for further details.

Table IV.29 Summary of Inputs and Methods for the National Impact Analysis

Inputs	Method
Shipments	Annual shipments from shipments model.
Compliance Date of Standard	2030
Efficiency Trends	No-new-standards case: Based on historical data. Standard cases: Roll-up in the compliance year and then DOE estimated growth in shipment-weighted efficiency in all the standards cases.
Annual Energy Consumption per Unit	Annual weighted-average values are a function of energy use at each TSL.
Total Installed Cost per Unit	Annual weighted-average values are a function of cost at each TSL. Incorporates projection of future product prices based on historical data.
Annual Energy Cost per Unit	Annual weighted-average values as a function of the annual energy consumption per unit and energy prices.
Repair and Maintenance Cost per Unit	Annual values do not change with efficiency level.
Energy Price Trends	*AEO2023* projections (to 2050) and extrapolation thereafter.
Energy Site-to-Primary and FFC Conversion	A time-series conversion factor based on *AEO2023*.
Discount Rate	Three and seven percent.
Present Year	2023

1. Product Efficiency Trends

A key component of the NIA is the trend in energy efficiency projected for the no-new-standards case and each of the standards cases. Section 0 of this document describes how DOE developed an energy efficiency distribution for the no-new-standards case (which yields a shipment-weighted average efficiency) for each of the considered product classes for the year of anticipated compliance with an amended or new standard. To project the trend in efficiency absent amended standards for consumer water heaters over the entire shipments projection period, DOE used available historical shipments data and manufacturer input. The approach is further described in chapter 10 of the final rule TSD.

For the standards cases, DOE used a "roll-up" scenario to establish the shipment-weighted efficiency for the year that standards are assumed to become effective (2030).

In this scenario, the market shares of products in the no-new-standards case that do not meet the standard under consideration would "roll up" to meet the new standard level, and the market share of products above the standard would remain unchanged.

To develop standards-case efficiency trends after 2030, DOE used historical shipment data and current consumer water heater model availability by efficiency level (*see* chapter 8). DOE estimated growth in shipment-weighted efficiency by assuming that the implementation of ENERGY STAR's performance criteria and other incentives would gradually increase the market shares of higher efficiency water heaters meeting ENERGY STAR requirements such as EL 3 and above for gas-fired storage water heaters and EL 2 and above for electric storage water heaters ($\geq$ 20 gal $V_{eff} \leq$ 55 gal).DOE also took into account increased incentives for higher efficiency equipment and electrification efforts. For oil-fired storage water heaters and electric storage water heaters (> 55 gal V_{eff} $\leq$ 120 gal), DOE assumed a constant market share throughout the analysis period (2030–2059).

BWC cautioned DOE against using ENERGY STAR performance criteria data to assume growth in market shares for higher efficiency water heaters after 2030 in the no-new-standards case. BWC noted that ENERGY STAR's Residential Water Heater Specification 4.0 (effective March 29, 2022, to April 18, 2023) incentivized the purchase of high efficiency water heater products, such as heat pump water heaters, but the penetration rate for these products in the market remains low, as ENERGY STAR's 2022 Unit Shipment and Market Penetration Report Summary reports only a 3-percent market penetration for these products. In contrast, Figure 10.2.2 of the NOPR TSD assumes heat pump water heaters making up 11 percent of the market by 2030 in the no-new-standards case, which appears unlikely when considering the information released by ENERGY STAR cited above. (BWC, No. 1164 at p. 3)

DOE derived its estimates based on multiple available data sources and shipments model, not just ENERGY STAR shipment data. DOE's estimated market share of higher efficiency equipment is based on these data as well as on existing policies and incentives that drive a higher adoption of higher efficiency equipment in the no-new-standards case, as discussed in more detail in appendix 8I and 9A. DOE notes that if the analysis assumed a lower market share projection of heat pump water heaters in the no-new-standards case, this would result in a higher estimate of energy savings from the adopted standards, which would only further support DOE's conclusion of economic justification.

2. National Energy Savings

The national energy savings analysis involves a comparison of national energy consumption of the considered products between each potential standards case ("TSL") and the case with no new or amended energy conservation standards. DOE calculated the national energy consumption by multiplying the number of units (stock) of each product (by vintage or age) by the unit energy consumption (also by vintage). DOE calculated annual NES based on the difference in national energy consumption for the no-new-standards case and for each higher efficiency standard case. DOE estimated energy consumption and savings based on site energy and converted the electricity consumption and savings to primary energy (*i.e.*, the energy consumed by power plants to generate site electricity) using annual conversion factors derived from *AEO2023*. Cumulative energy savings are the sum of the NES for each year over the timeframe of the analysis.

Use of higher-efficiency products is sometimes associated with a direct rebound effect, which refers to an increase in utilization of the product due to the increase in efficiency. DOE examined a 2009 review of empirical estimates of the rebound effect for various energy-using products.[142] This review concluded that the econometric and quasi-experimental studies suggest a mean value for the direct rebound effect for household water heating of around 10 percent. DOE also examined a 2012 ACEEE paper[143] and a 2013 paper by Thomas and Azevedo.[144] Both of these publications examined the same studies that were reviewed by Sorrell, as well as Greening *et al.*,[145] and identified methodological problems with some of the studies. The studies believed to be most reliable by Thomas and Azevedo show a direct rebound effect for water heating products in the 1-percent to 15-percent range, while Nadel concludes that a more likely range is 1 to 12 percent, with rebound effects sometimes higher for low-income households that could not afford to adequately heat their homes prior to weatherization. DOE applied a rebound effect of 10 percent for consumer water heaters used in residential applications based on studies of other residential products and the value used for consumer water

142 Steven Sorrell, *et al.*, Empirical Estimates of the Direct Rebound Effect: A Review, 37 *Energy Policy* 1356–71 (2009). Available at *www.sciencedirect.com/science/article/pii/S0301421508007131* (last accessed Dec. 1, 2023).
143 Steven Nadel, "The Rebound Effect: Large or Small?" ACEEE White Paper (August 2012). Available at *www.aceee.org/files/pdf/white-paper/rebound-large-and-small.pdf* (last accessed Dec. 1, 2023).
144 Brinda Thomas and Ines Azevedo, Estimating Direct and Indirect Rebound Effects for U.S. Households with Input–Output Analysis, Part 1: Theoretical Framework, 86 *Ecological Econ*. 199–201 (2013). Available at *www.sciencedirect.com/science/article/pii/S0921800912004764*) (last accessed Dec. 1, 2023).
145 Lorna A. Greening, *et al.*, Energy Efficiency and Consumption—The Rebound Effect—A Survey, 28 *Energy Policy* 389–401 (2002). Available at *www.sciencedirect.com/science/article/pii/S0301421500000215* (last accessed Dec. 1, 2023).

heaters in the 2010 Final Rule for Heating Products, and 0 percent for consumer water heaters in commercial applications, which also matches EIA's National Energy Modeling System ("NEMS") for residential and commercial water heating and is consistent with other recent energy conservation standards rulemakings.[146,147,148,149] The calculated NES at each efficiency level is therefore reduced by 10 percent in residential applications. DOE also included the rebound effect in the NPV analysis by accounting for the additional net benefit from increased consumer water heaters usage, as described in section IV.H.3 of this document.

In 2011, in response to the recommendations of a committee on "Point-of-Use and Full-Fuel-Cycle Measurement Approaches to Energy Efficiency Standards" appointed by the National Academy of Sciences, DOE announced its intention to use FFC measures of energy use and greenhouse gas and other emissions in the national impact analyses and emissions analyses included in future energy conservation standards rulemakings. 76 FR 51281 (Aug. 18, 2011). After evaluating the approaches discussed in the August 18, 2011 notice, DOE published a statement of amended policy in which DOE explained its determination that EIA's National Energy Modeling System ("NEMS") is the most appropriate tool for its FFC analysis and its intention to use NEMS

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[146] *See www.eia.gov/outlooks/aeo/nems/documentation/residential/pdf/m067(2020).pdf* (last accessed Dec. 1, 2023

[147] DOE. Energy Conservation Program for Certain Industrial Equipment: Energy Conservation Standards for Small, Large, and Very Large Air-Cooled Commercial Package Air Conditioning and Heating Equipment and Commercial Warm Air Furnaces; Direct final rule. 81 FR 2419 (Jan. 15, 2016). Available at *www.regulations.gov/document/EERE-2013-BT-STD-0021-0055* (last accessed Dec. 1, 2023).

[148] DOE. Energy Conservation Program: Energy Conservation Standards for Residential Boilers; Final rule. 81 FR 2319 (Jan. 15, 2016). Available at *www.regulations.gov/document/EERE-2012-BT-STD-0047-0078* (last accessed Dec. 1, 2023).

[149] DOE. Energy Conservation Program: Energy Conservation Standards for Commercial Packaged Boilers; Final Rule. 85 FR 1592 (Jan. 10, 2020). Available at *www.regulations.gov/document/EERE-2013-BT-STD-0030-0099* (last accessed Dec. 1, 2023).

for that purpose. 77 FR 49701 (Aug. 17, 2012). NEMS is a public domain, multi-sector, partial equilibrium model of the U.S. energy sector[150] that EIA uses to prepare its *Annual Energy Outlook.* The FFC factors in corporate losses in production and delivery in the case of natural gas (including fugitive emissions) and additional energy used to produce and deliver the various fuels used by power plants. The approach used for deriving FFC measures of energy use and emissions is described in appendix 10B of the final rule TSD.

EEI commented that the fossil fuel equivalency methodology, employed in DOE's impact assessment of proposed changes to efficiency standards, was developed in an earlier era when the penetration of renewable energy generation was low. EEI commented that continuing to apply fossil fuel equivalency factors leads to the false conclusion that renewable energy generation has the same primary energy losses as fossil generation and that these energy losses represent similar economic loss. EEI stated that EIA is moving to the captured energy approach in all of its analyses as of June 2023, and DOE should follow EIA's lead and update its methodology as soon as possible to create more realistic estimates of primary energy savings and electricity sector emissions reductions. (EEI, No. 1198 at pp. 6-8)

As previously mentioned, DOE converts electricity consumption and savings to primary energy using annual conversion factors derived from the EIA's *AEO2023*. Traditionally, EIA has used the fossil fuel equivalency approach to report noncombustible renewables' contribution to total primary energy. The fossil fuel

[150] For more information on NEMS, refer to *The National Energy Modeling System: An Overview 2009*, DOE/EIA-0581(2009), October 2009. Available at *www.eia.gov/forecasts/aeo/index.cfm* (last accessed Dec. 1, 2023).

equivalency approach applies an annualized weighted-average heat rate for fossil fuel power plants to the electricity generated (in kWh) from noncombustible renewables. EIA recognizes that using captured energy (the net energy available for direct consumption after transformation of a noncombustible renewable energy into electricity) or incident energy (the mechanical, radiation, or thermal energy that is measurable as the "input" to the device) are possible approaches for converting renewable electricity to a common measure of primary energy, but used the fossil fuel equivalency approach in *AEO2023* and other reporting of energy statistics used in this final rule. DOE contends that it is important for it to maintain consistency with *AEO2023* in DOE’s accounting of primary energy savings from energy efficiency standards.

3. Net Present Value Analysis

The inputs for determining the NPV of the total costs and benefits experienced by consumers are (1) total annual installed cost, (2) total annual operating costs (energy costs and repair and maintenance costs), and (3) a discount factor to calculate the present value of costs and savings. DOE calculates net savings each year as the difference between the no-new-standards case and each standards case in terms of total savings in operating costs versus total increases in installed costs. DOE calculates operating cost savings over the lifetime of each product shipped during the projection period.

As discussed in section IV.F.1 of this document, DOE used constant prices as the default price assumption to project future consumer water heater prices. However, DOE also developed consumer water heater price trends based on historical PPI data. DOE applied the same trends to project prices for each product class at each considered efficiency level as a sensitivity analysis. DOE's projection of product prices is described in appendix 10C of the final rule TSD.

To evaluate the effect of uncertainty regarding the price trend estimates, DOE investigated the impact of different product price projections on the consumer NPV for the considered TSLs for consumer water heaters. In addition to the default price trend, DOE considered two product price sensitivity cases: (1) a price decline case and (2) price increase case based on PPI data. The derivation of these price trends and the results of these sensitivity cases are described in appendix 10C of the final rule TSD.

The energy cost savings are calculated using the estimated energy savings in each year and the projected price of the appropriate form of energy. To estimate energy prices in future years, DOE multiplied the average regional energy prices by the projection of annual national-average residential energy price changes in the Reference case from *AEO2023*, which has an end year of 2050. To estimate price trends after 2050, the 2046–2050 average was used for all years. As part of the NIA, DOE also analyzed scenarios that used inputs from variants of the *AEO2023* Reference case that have lower and higher economic growth. Those cases have lower and higher energy price trends compared to the Reference case. NIA results based on these cases are presented in appendix 10C of the final rule TSD.

In considering the consumer welfare gained due to the direct rebound effect, DOE accounted for change in consumer surplus attributed to additional water heating from the purchase of a more efficient unit. Overall consumer welfare is generally understood to be enhanced from rebound. The net consumer impact of the rebound effect is included in the calculation of operating cost savings in the consumer NPV results. *See* appendix 10E of the final rule TSD for details on DOE's treatment of the monetary valuation of the rebound effect.

In calculating the NPV, DOE multiplies the net savings in future years by a discount factor to determine their present value. For this final rule, DOE estimated the NPV of consumer benefits using both a 3-percent and a 7-percent real discount rate. DOE uses these discount rates in accordance with guidance provided by the Office of Management and Budget ("OMB") to Federal agencies on the development of regulatory analysis.[151] The discount rates for the determination of NPV are in contrast to the discount rates used in the LCC analysis, which are designed to reflect a consumer's perspective. The 7-percent real value is an estimate of the average before-tax rate of return to private capital in the U.S. economy. The 3-percent real value represents the "social rate of time preference," which is the rate at which society discounts future consumption flows to their present value.

Atmos Energy argued that increased efficiency in water heaters could lead to an increase in water usage which could further drought in southern and western states. Atmos Energy argued that a full evaluation of rebound effects of the proposal should be conducted and that increased water usage should be calculated and evaluated as an environmental cost of the proposal. (Atmos Energy, No. 1183 at p. 5)

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[151] U.S. Office of Management and Budget. *Circular A-4: Regulatory Analysis*. Available at *www.whitehouse.gov/omb/information-for-agencies/circulars* (last accessed Mar. 5, 2024). DOE used the prior version of Circular A-4 (September 17, 2003) in accordance with the effective date of the November 9, 2023 version. Available at https://www.whitehouse.gov/wp-content/uploads/legacy_drupal_files/omb/circulars/A4/a-4.pdf (last accessed Dec. 1, 2023).

DOE has considered rebound effects in its analysis. DOE notes that the impacts of changes in water usage on regional water supply are not captured within the scope of DOE's standards analysis.

I. Consumer Subgroup Analysis

In analyzing the potential impact of new or amended energy conservation standards on consumers, DOE evaluates the impact on identifiable subgroups of consumers that may be disproportionately affected by a new or amended national standard. The purpose of a subgroup analysis is to determine the extent of any such disproportional impacts. DOE evaluates impacts on particular subgroups of consumers by analyzing the LCC impacts and PBP for those particular consumers from alternative standard levels. For this final rule, DOE analyzed the impacts of the considered standard levels on three subgroups: (1) low-income households, (2) senior-only households, and (3) small businesses. The analysis used subsets of the RECS 2020 sample composed of households and CBECS 2018 sample composed of commercial buildings that meet the criteria for the three subgroups. DOE used the LCC and PBP spreadsheet model to estimate the impacts of the considered efficiency levels on these subgroups. Chapter 11 in the FR TSD describes the consumer subgroup analysis.

1. Low-income Households

Low-income households are significantly more likely to be renters or live in subsidized housing units and less likely to be homeowners. DOE notes that in these cases, the landlord purchases the equipment and may pay the gas bill as well. RECS 2020 includes data on whether a household pays for the gas bill, allowing DOE to categorize households appropriately in the analysis.[152] For this consumer subgroup analysis, DOE considers the impact on the low-income household narrowly, excluding any costs or benefits that are accrued by either a landlord or subsidized housing agency. This allows DOE to determine whether low-income households are disproportionately affected by an amended energy conservation standard in a more representative manner. DOE takes into account a fraction of renters that face product switching (when landlords switch to products that have lower upfront costs but higher operating costs, which will be incurred by tenants).

The majority of low-income households that experience a net cost at higher efficiency levels are homeowner households, as opposed to renters. These households either have a smaller capacity water heater or lower hot water use. Unlike renters, homeowners would bear the full cost of installing a new water heater. For these households, a potential rebate program to reduce the total installed costs would be effective in lowering the percentage of low-income consumers with a net cost. DOE understands that the landscape of low-income consumers with a water heater may change before the compliance date of amended energy conservation standards, if finalized. For example, point-of-sale rebate programs are being considered that may moderate the impact on low-income consumers to help offset the total installed cost of a higher efficiency water heater, particularly given the lower total installed cost of smaller capacity water heater. Currently, DOE is aware that the Inflation Reduction Act will likely include incentives for certain water heaters, although the specific implementation

[152] RECS 2020 includes a category for households that pay only some of the gas bill. For the low-income consumer subgroup analysis, DOE assumes that these households pay 50 percent of the gas bill, and, therefore, would receive 50 percent of operating cost benefits of an amended energy conservation standard.

details have yet to be finalized. DOE is also aware of State or utility program rebates in the Northeast or California, for example, that support additional heat pump deployment as a result of decarbonization policy goals. Point-of-sale rebates or weatherization programs could also reduce the total number of low-income consumers that would be impacted because the household no longer has a water heater to upgrade.

BWC cautioned DOE against relying as heavily as it does in this proposal on state, local, and/or utility rebate programs to decrease the upfront installation costs for condensing gas-fired water heaters, as well as heat pump water heaters. While recognizing the existence of many rebate programs today, BWC questions how many of these rebates will continue in place if the Department finalizes this proposal. This is therefore a scenario BWC urged DOE to account for in its subgroup analysis as BWC believes it will reveal cost burdens that are much higher on the low-income households than what is presently assumed in this NOPR. (BWC, No. 1164 at p. 19). For consumers in subsidized housing, BWC urged the Department to consider two realistic outcomes regarding product rebates that are designed to cover upfront installation costs. The first is that many or all third parties will stop offering these rebates once federal, state, and/or local regulatory bodies require the use of high-efficiency appliances. (BWC No. 1164 at p. 26) The second is the cost that these consumers will experience when their highly efficient product reaches the end of its useful life. Many rebate programs are designed to assist consumers with project costs associated with fuel-switching or upgrading a lower efficiency product with a more expensive, higher efficiency counterpart. However, many if not most of these rebate programs do not apply to installations where a highly efficient product is undergoing a like-for-like replacement. (BWC No. 1164 at p. 27)

Rheem argued that IRA will not impact water heaters sold at the efficiency levels proposed by DOE; therefore, low-income households will not benefit from 25C tax credits. Rheem pointed out that Energy Star specification has recently been updated and recommended that DOE address the new levels. This includes that Energy Star has indicated that they will sunset gas-fired water heater specification and therefore should not be used to determine uptake of higher efficiency gas-fired WH. (Rheem, No. 1177 at pp. 16-17).

In response to the above comments regarding rebates, DOE clarifies that it does not rely on the existence of rebate programs to justify the energy conservation standards. DOE’s installation costs are estimated based on labor and material costs, as described in chapter 8 and appendix 8D, without any rebates. DOE merely notes that the potential existence of such programs in the future would only improve the economic justification of this rule.

Health Advocates and Joint Advocates of Energy Efficiency argued that 67 percent of low-income households face a high-energy burden where they must spend 3 times more of their income on energy costs compared to median spending (8.1 percent vs 2.3 percent). Health Advocates argued that renters (disproportionately low-income households) would benefit from this rule because landlords have no incentive to install efficient water heaters as tenants usually pay the energy bills. (Health Advocates, No. 1179 at p. 2; Joint Advocates of Energy Efficiency, No. 1165 at p. 2) In response, DOE notes that it has considered the impacts on low-income households. Low-income homeowners (including owners of manufactured homes) are more likely to have smaller water heaters that either are not subject to amended standards (in the case of small

ESWHs) or have modest incremental costs. Low-income renters are unlikely to bear the equipment and installation costs of replacing their water heater but are more likely to pay energy costs and therefore see operating benefits from the rule. DOE has evaluated the full distribution of impacts in the LCC analysis, including consumers that experience a net cost and consumers that experience a net benefit, and concludes that on the whole, the rule is economically justified.

Gas Association Commenters argued that if better regional market share data were used, regions with low or negative LCC savings would impact the overall outcome differently. Gas Association Commenters included tables in their submitted comment summarizing these argued regional impacts. Gas Association Commenters also argued that DOE is missing subsets of low-income households by only using those who are most likely to directly pay utility bills. They stated that utilities can also be a function of rent where higher utility costs can still be passed on to the end user. (Gas Association Commenters, No. 1181 at p. 6 and pp. 23-25) DOE acknowledges that there may be some regional variation in LCC impacts and these results are available in the LCC spreadsheet. DOE further acknowledges that some fraction of consumers will experience a net cost, as presented in the LCC. However, DOE concludes that on the whole, the rule continues to be economically justified, with the incorporation of a much larger RECS 2020 sample. The average LCC savings remain positive. With respect to low-income households, DOE took into account both scenarios where the households do or do not directly pay their utility bills, and these are included in the low-income subgroup analysis as discussed in chapter 11.

NRECA commented that the subgroup is too narrowly defined to include low-income homeowners and urged DOE to account for consumers near but above the poverty level who can also experience a high burden when the installation cost for a heat pump water heater easily takes up 10 percent of their annual income. NRECA also noted that manufactured housing comprises 25 percent or more of the co-op's residential housing stock and that these same homes present challenges for heat pump water heater adoption due to space constraints. NRECA suggested that DOE should improve its analysis by using low-and-moderate income instead of poverty-level in the subgroup and assigning proportionally higher occurrences of expensive installations to this subgroup. (NRECA, No. 1127 at pp. 5-6) In contrast, NYSERDA commented that the proposed standard will bring significant benefits to low-and-moderate income households and to disadvantaged communities. (NYSERDA, No. 1192 at p. 3) DOE notes that the low-income subgroup is specifically defined for households meeting poverty thresholds, as defined in chapter 11. While households slightly above these thresholds are not included in the low-income subgroup analysis, they are part of the overall LCC analysis. On the whole, DOE concludes that the rule is economically justified for both the overall LCC consumer sample as well as the low-income subgroup. Households that do not meet the low-income threshold but are nonetheless energy insecure are likely to experience impacts that fall in between the overall LCC results and the low-income subgroup results, which would still be economically justified. As noted above, energy insecure homeowners with smaller water heaters will either experience smaller incremental equipment costs on average or have water heaters not subject to amended standards, and energy insecure renters would benefit similarly to low-income renters.

ECSC argued that heat pump water heater installations will be hindered by lack of contractor availability in rural areas. (ECSC, No. 1185 at pp. 1-2) Regarding contractor availability, DOE notes that while heat pump water heaters are not as common today, they will become very common by the compliance date of the rule. Many contractors at present are able to install different types of water heaters, including heat pump water heaters. At the adopted standard level, the existing market for small electric storage water heaters is preserved, which reduces the level of contractor training and investment needed than if higher standards were adopted for all electric storage water heaters. While DOE acknowledges there is a ramp up in contractor training required by 2030, the adopted standard level allows for a more incremental transition to heat pump technology. Furthermore, DOE notes that the emergence of workforce programs supported by the Inflation Reduction Act and the Bipartisan Infrastructure Law will begin to support the training and education of the workforce needed to support the clean energy transition.

BWC disagreed with the Department excluding any costs or benefits that are accrued by a landlord when analyzing impacts to the low-income household subgroup. While BWC understood that these costs and benefits are not imposed directly on renters, they will indirectly lead to impacts on renters that DOE should account for, such as increased rent rates resulting from landlords attempting to recoup the initial project installation costs, as well as increased maintenance costs likely to result for the installation of a higher efficiency product. (BWC No. 1164 at p. 26) Armada argued that DOE failed to acknowledge that landlords will be forced to increase rent or other costs to cover the purchase and installation of more efficient options, and a landlord will have to dedicate a bedroom to a water heater or reconfigure the duct-work of the property to accommodate the water heater. Armada argued that these are major changes that will harm residents the most, and these proposed efficiency standards which will effectively mandate heat pump technology will only compound the existing affordable housing issue. (Armada, No. 1193 at pp. 6-7) DOE finds no evidence that significant rental cost increases would occur. Rental prices are largely dictated by supply and demand of housing in individual locations, not the sum of equipment costs in those rentals, such that two similar rentals could have widely differing prices in different cities. Furthermore, a landlord would be responsible for replacing an end-of-life water heater in the no-new-standards case as well yet the rent is unlikely to increase simply because of this regular maintenance. The installation costs estimated in the LCC already include any potential replacement of venting for gas-fired water heaters and other installation costs for ESWHs, however there is never a need to "dedicate a bedroom" to a new water heater. Additionally, even if there are significant extra costs for the installation of a heat pump water heater (see section IV.F.2.d), the analysis includes the potential to switch to a small ESWH for consumers with lower hot water demand as an alternative to minimize installation costs (see section IV.G.1). Finally, even if a landlord were to fully pass on the incremental costs due to amended standards, those costs would presumably be spread out over a monthly rent spanning many years, possibly the lifetime of the water heater, resulting in relatively small monthly rent increases. It is for these reasons that the low-income subgroup analyzes impacts assuming renters do not bear installation costs. However, as described in section IV.F, for the overall LCC analysis, DOE makes the simplifying assumption that all installation and equipment costs are paid for by the consumer of the equipment, including renters. Therefore, the main LCC results do assume that landlords pass on all costs and yet the analysis still finds that the rule is economically justified.

For consumers in subsidized housing, BWC urged the Department to consider two realistic outcomes regarding product rebates that are designed to cover upfront installation costs. The first is that many or all third parties will stop offering these rebates once federal, state, and/or local regulatory bodies require the use of high-efficiency appliances. (BWC No. 1164 at p. 26) The second is the cost that these consumers will experience when their highly efficient product reaches the end of its useful life. Many rebate programs are designed to assist consumers with project costs associated with fuel-switching or upgrading a lower efficiency product with a more expensive, higher efficiency counterpart. However, many if not most of these rebate programs do not apply to installations where a highly efficient product is undergoing a like-for-like replacement. (BWC No. 1164 at p. 27)

DOE clarifies that the analysis does not assume that installation costs are reduced by rebates or incentives. Rather, the analysis uses these existing programs as part of the shipments projection and the projection of market shares at different efficiency levels in the no-new-standards case. This merely characterizes the market up to the compliance date of the adopted standards.

2. Senior-Only Households

Senior-only households are households with occupants who are all at least 65 years of age. RECS 2020 includes information on the age of household occupants, allowing for the identification of senior-only households from the sample. Senior-only households comprised 23.5 percent of the country's households. In estimating the LCC impacts to senior-only households, it is assumed that any residual value of a long-lived product is capitalized in the value of the home.

3. Small Business Subgroup

DOE identified small businesses in CBECS 2018 using threshold levels for maximum number of employees within each building principal building activity. DOE received no comments regarding small businesses impacts relevant to products within the scope of this final rule.

J. Manufacturer Impact Analysis

1. Overview

DOE performed an MIA to estimate the financial impacts of amended energy conservation standards on manufacturers of consumer water heaters and to estimate the potential impacts of such standards on direct employment and manufacturing capacity. The MIA has both quantitative and qualitative aspects and includes analyses of projected industry cash flows, the INPV, investments in research and development ("R&D") and manufacturing capital, and domestic manufacturing employment. Additionally, the MIA seeks to determine how amended energy conservation standards might affect manufacturing employment, capacity, and competition, as well as how standards contribute to overall regulatory burden. Finally, the MIA serves to identify any disproportionate impacts on manufacturer subgroups, including small business manufacturers.

The quantitative part of the MIA primarily relies on the GRIM, an industry cash flow model with inputs specific to this rulemaking. The key GRIM inputs include data on the industry cost structure, unit production costs, product shipments, manufacturer markups, and investments in R&D and manufacturing capital required to produce compliant products. The key GRIM outputs are the INPV, which is the sum of industry annual cash flows over the analysis period, discounted using the industry-weighted average cost of capital, and the impact to domestic manufacturing employment. The model uses standard accounting principles to estimate the impacts of more stringent energy conservation standards on a given industry by comparing changes in INPV and domestic manufacturing employment between a no-new-standards case and the various standards cases. To capture the uncertainty relating to manufacturer pricing strategies following amended standards, the GRIM estimates a range of possible impacts under different manufacturer markup scenarios.

The qualitative part of the MIA addresses manufacturer characteristics and market trends. Specifically, the MIA considers such factors as a potential standard's impact on manufacturing capacity, competition within the industry, the cumulative impact of other DOE and non-DOE regulations, and impacts on manufacturer subgroups. The complete MIA is outlined in chapter 12 of the final rule TSD.

DOE conducted the MIA for this rulemaking in three phases. In Phase 1 of the MIA, DOE prepared a profile of the consumer water heater manufacturing industry based on the market and technology assessment, preliminary manufacturer interviews, and publicly available information. This included a top-down analysis of consumer water heater manufacturers that DOE used to derive preliminary financial inputs for the GRIM (*e.g.*, revenues; materials, labor, overhead, and depreciation expenses; selling, general, and administrative expenses ("SG&A"); and R&D expenses). DOE also used public sources of information to further calibrate its initial characterization of the consumer water heater manufacturing industry, including company filings of form 10-K from the SEC,[153] corporate annual reports, the U.S. Census Bureau's *Quarterly Survey of Plant Capacity Utilization,*[154] U.S. Census Bureau's *Annual Survey of Manufactures* ("*ASM*"),[155] and reports from D&B Hoovers.[156]

In Phase 2 of the MIA, DOE prepared a framework industry cash-flow analysis to quantify the potential impacts of amended energy conservation standards. The GRIM uses several factors to determine a series of annual cash flows starting with the announcement of the standard and extending over a 30-year period following the compliance date of the standard. These factors include annual expected revenues, costs of sales, SG&A and R&D expenses, taxes, and capital expenditures. In general, energy conservation standards can affect manufacturer cash flow in three distinct ways: (1) creating a need for increased investment, (2) raising production costs per unit, and (3) altering revenue due to higher per-unit prices and changes in sales volumes.

In addition, during Phase 2, DOE developed interview guides to distribute to manufacturers of consumer water heaters in order to develop other key GRIM inputs, including product and capital conversion costs, and to gather additional information on

[153]U.S. Securities and Exchange Commission. Company Filings. Available at*www.sec.gov/edgar/searchedgar/companysearch.html* (last accessed Aug. 2, 2022).
[154]The U.S. Census Bureau. Quarterly Survey of Plant Capacity Utilization. Available at *www.census.gov/programs-surveys/qpc/data/tables.html* (last accessed Aug. 2, 2022).
[155] U.S. Census Bureau's Annual Survey of Manufactures: 2018-2021 (Available at: www.census.gov/programs-surveys/asm/data/tables.html) (last accessed January 18, 2024).
[156]The D&B Hoovers login is available at *app.dnbhoovers.com* (last accessed Dec. 1, 2023).

the anticipated effects of energy conservation standards on revenues, direct employment, capital assets, industry competitiveness, and subgroup impacts.

In Phase 3 of the MIA, DOE conducted structured, detailed interviews with representative manufacturers. During these interviews, DOE discussed engineering, manufacturing, procurement, and financial topics to validate assumptions used in the GRIM and to identify key issues or concerns. As part of Phase 3, DOE also evaluated subgroups of manufacturers that may be disproportionately impacted by amended standards or that may not be accurately represented by the average cost assumptions used to develop the industry cash flow analysis. Such manufacturer subgroups may include small business manufacturers, low-volume manufacturers, niche players, and/or manufacturers exhibiting a cost structure that largely differs from the industry average. DOE identified one subgroup for a separate impact analysis: small business manufacturers. The small business subgroup is discussed in section VI.B of this document, "Review under the Regulatory Flexibility Act" and in chapter 12 of the final rule TSD.

2. Government Regulatory Impact Model and Key Inputs

DOE uses the GRIM to quantify the changes in cash flow due to new or amended standards that result in a higher or lower industry value. The GRIM uses a standard, annual, discounted cash-flow analysis that incorporates manufacturer costs, manufacturer markups, shipments, and industry financial information as inputs. The GRIM models changes in costs, distribution of shipments, investments, and manufacturer margins that could result from an amended energy conservation standard. The GRIM spreadsheet uses the inputs to arrive at a series of annual cash flows, beginning in 2023 (the base year of the analysis) and continuing to 2059. DOE calculated INPVs by summing the stream of annual discounted cash flows during this period. For manufacturers of consumer water heaters, DOE used a real discount rate of 9.3 percent, which was derived from industry financials and then modified according to feedback received during manufacturer interviews.

The GRIM calculates cash flows using standard accounting principles and compares changes in INPV between the no-new-standards case and each standards case. The difference in INPV between the no-new-standards case and a standards case represents the financial impact of the new or amended energy conservation standard on manufacturers. As discussed previously, DOE developed critical GRIM inputs using a number of sources, including publicly available data, results of the engineering analysis, and information gathered from industry stakeholders during the course of manufacturer interviews. The GRIM results are presented in section V.B.2 of this document. Additional details about the GRIM, the discount rate, and other financial parameters can be found in chapter 12 of the final rule TSD.

a. Manufacturer Production Costs

Manufacturing more efficient products is typically more expensive than manufacturing baseline products due to the use of more complex components, which are typically more costly than baseline components. The changes in the MPCs of covered products can affect the revenues, gross margins, and cash flow of the industry.

As discussed in section IV.C.1 of this document, DOE conducted a market analysis of currently available models listed in DOE's CCD to determine which efficiency levels were most representative of the current distribution of consumer water heaters available on the market. DOE also completed physical teardowns of commercially available units to determine which design options manufacturers may use to achieve certain efficiency levels for each water heater category analyzed. DOE requested comments from stakeholders and conducted interviews with manufacturers concerning these initial efficiency levels, which have been updated based on the feedback DOE received. For a complete description of the MPCs, *see* section IV.C of this document and chapter 5 of the final rule TSD.

b. Shipments Projections

The GRIM estimates manufacturer revenues based on total unit shipment projections and the distribution of those shipments by efficiency level. Changes in sales volumes and efficiency mix over time can significantly affect manufacturer finances. For this analysis, the GRIM uses the NIA's annual shipment projections derived from the shipments analysis from 2023 (the base year) to 2059 (the end year of the analysis period). *See* section IV.G of this document and chapter 9 of the final rule TSD for additional details.

c. Product and Capital Conversion Costs

Amended energy conservation standards could cause manufacturers to incur conversion costs to bring their production facilities and equipment designs into compliance. DOE evaluated the level of conversion-related expenditures that would be needed to comply with each considered efficiency level in each product class. For the MIA, DOE classified these conversion costs into two major groups: (1) product conversion costs; and (2) capital conversion costs. Product conversion costs are investments in research, development, testing, marketing, and other non-capitalized costs necessary to make product designs comply with amended energy conservation standards. Capital conversion costs are investments in property, plant, and equipment necessary to adapt or change existing production facilities such that new compliant product designs can be fabricated and assembled.

To evaluate the level of product conversion costs manufacturers would likely incur to comply with amended energy conservation standards, DOE relied on feedback from manufacturer interviews. DOE contractors conducted interviews with manufacturers of gas-fired storage, gas-fired instantaneous, oil-fired storage, electric storage, electric instantaneous, tabletop, and grid-enabled water heaters. The interviewed manufacturers account for approximately 84 percent of sales of consumer water heaters covered by this rulemaking. DOE used market share weighted feedback from interviews to extrapolate industry-level product conversion costs from the manufacturer feedback.

To evaluate the level of capital conversion costs manufacturers would likely incur to comply with amended energy conservation standards, DOE relied on estimates of equipment and tooling from its engineering analysis and on feedback from manufacturer interviews. DOE modeled the green field investments required for a major manufacturer to set up a production facility. The investment figures included capital required for manufacturing equipment, tooling, conveyors, and facility. DOE then modeled the incremental investment required by more stringent standards. DOE multiplied the incremental investment by the number of "major" (*i.e.*, high-volume) manufacturers. These investment levels aligned with feedback from interviews. Additionally, DOE determined that smaller manufacturers would have lower investment levels given their lower production volumes, relative to "major" manufacturers, and accounted for those lower investments for manufacturers with lower market share. DOE updated its conversion cost estimates for the product classes analyzed in this final rule by incorporating refined equipment, tooling, conveyor, and space estimates generated from the product teardown analysis, but otherwise maintained its conversion cost methodology from the July 2023 NOPR.

In general, DOE assumes all conversion-related investments occur between the year of publication of the final rule and the year by which manufacturers must comply with the new standard. The conversion cost figures used in the GRIM can be found in section V.B.2 of this document. For additional information on the estimated product and capital conversion costs, *see* chapter 12 of the final rule TSD.

d. Manufacturer Markup Scenarios

MSPs include direct manufacturing production costs (*i.e.*, labor, materials, and overhead estimated in DOE's MPCs) and all non-production costs (*i.e.*, SG&A, R&D, and interest), along with profit. To calculate the MSPs in the GRIM, DOE applied manufacturer markups to the MPCs estimated in the engineering analysis for each analyzed product class and efficiency level. Modifying these manufacturer markups in the standards case yields different sets of impacts on manufacturers. For the MIA, DOE modeled two standards-case manufacturer markup scenarios to represent uncertainty regarding the potential impacts on prices and profitability for manufacturers following the implementation of amended energy conservation standards: (1) a preservation of gross margin percentage scenario; and (2) a preservation of operating profit scenario. These scenarios lead to different manufacturer markup values that, when applied to the MPCs, result in varying revenue and cash flow impacts.

Under the preservation of gross margin percentage scenario, DOE applied a single uniform "gross margin percentage" across all efficiency levels, which assumes that manufacturers would be able to maintain the same amount of profit as a percentage of revenues at all efficiency levels within a product class. As MPCs increase with efficiency, this scenario implies that the per-unit dollar profit will increase. DOE estimated gross margin percentages of 24 percent for the gas-fired storage water heaters, 22 percent for electric storage water heaters, and 23 percent for oil-fired storage water heaters.[157] Manufacturers tend to believe it is optimistic to assume that they would be able to maintain the same gross margin percentage as their production costs increase, particularly for minimally efficient products. Therefore, this scenario represents a high bound to industry profitability under an amended energy conservation standard.

Under the preservation of operating profit scenario, DOE modeled a situation in which manufacturers are not able to increase per-unit operating profit in proportion to increases in MPCs. In the preservation of operating profit scenario, as the cost of production goes up under a standards case, manufacturers are generally required to

[157] The gross margin percentage of 24 percent for gas-fired storage is based on a manufacturer markup of 1.31. The gross margin percentage of 22 percent for electric storage is based on a manufacturer markup of 1.28. The gross margin percentage of 23 percent for oil-fired storage is based on a manufacturer markup of 1.30.

reduce their manufacturer markups to a level that maintains base-case operating profit. DOE implemented this scenario in the GRIM by lowering the manufacturer markups at each TSL to yield approximately the same earnings before interest and taxes in the standards case as in the no-new-standards case in the year after the compliance date of the amended standards. The implicit assumption behind this scenario is that the industry can only maintain its operating profit in absolute dollars after the standard.

A comparison of industry financial impacts under the two scenarios is presented in section V.B.2.a of this document.

3. Discussion of MIA Comments

a. Conversion Costs

In response to the July 2023 NOPR, BWC submitted written comments about the accuracy of DOE's conversion cost estimates. BWC stated that it continues to appreciate DOE considering conversion costs as part of its analysis. However, BWC asserted that the industry conversion costs DOE estimated in the July 2023 NOPR are understated and far lower than the cost that manufacturers will realistically incur. BWC offered to discuss these findings during confidential conversation with the consultants that DOE engaged for this rulemaking. (BWC, 1164 at pp. 4–5)

AHRI asserted that under the standards proposed in the July 2023 NOPR, manufacturers would need to produce exponentially more heat pump water heaters, requiring many manufacturers to build new plants, retrofit existing lines, or both.

Additionally, AHRI expressed concern that supply chains and labor shortages could compound these difficulties. (AHRI, No. 1167 at p. 12)

To evaluate the level of conversion costs industry would likely incur to comply with potential amended energy conservation standards, DOE relied on feedback from confidential manufacturer interviews and estimates of equipment, tooling, conveyor, and space from the engineering and product teardown analyses. DOE interviewed a range of manufacturers in advance of the July 2023 NOPR, which together account for approximately 84 percent of U.S. sales of consumer water heaters covered by this final rule. For this final rule, DOE reexamined its conversion cost estimates from the July 2023 NOPR. For all product classes analyzed in this final rule, DOE updated its conversion cost estimates by incorporating refined equipment, tooling, conveyor, and space estimates generated from the product teardown analysis, but otherwise maintained its conversion cost methodology from the July 2023 NOPR. *See* section IV.J.2.c of this document and chapter 12 of the final rule TSD for additional details on DOE's conversion cost methodology and investment estimates.

In response to the July 2023 NOPR, AHRI stated that it supported the inclusion of amortization of product conversion costs under standards into the projected MSP in a recent rulemaking for microwave ovens, and urges DOE to use this methodology in all rulemakings.[158] AHRI further asked DOE to explain the justification for amortizing conversion costs in one instance but not in all. (AHRI, No. 1167 at pp. 20-21)

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[158] Technical Support Document: Energy Efficiency Program For Commercial And Industrial Equipment: Microwave Ovens. Available at *www.regulations.gov/document/EERE-2017-BT-STD-0023-0022*.

DOE models different standards-case manufacturer markup scenarios to represent uncertainty regarding the potential impacts on prices and profitability for manufacturers following the implementation of amended energy conservation standards. The analyzed manufacturer markup scenarios vary by rulemaking as they are meant to reflect the potential range of financial impacts for manufacturers of the specific covered product or equipment. For the July 2023 NOPR, DOE applied a preservation of gross margin percentage scenario to reflect an upper bound to industry profitability under amended standards and a preservation of operating profit scenario to reflect a lower bound of industry profitability under amended standards. 88 FR 49058, 49128. For consumer water heaters, manufacturing more efficient products is generally more expensive than manufacturing baseline or minimally efficient products, as reflected by the MPCs estimated in the engineering analysis (*see* section IV.C.1.e of this document). Under the preservation of gross margin scenario for consumer water heaters, incremental increases in MPCs at higher efficiency levels result in an increase in per-unit dollar profit per unit sold. As shown in Table V.18, under the preservation of gross margin scenario, the standards case INPV increases relative to the no-new-standards case INPV for the adopted TSL (*i.e.*, TSL 2). This implies that the increase in cashflow from the higher MSP is outweighed by the estimated conversion costs at the adopted level. In other words, under the preservation of gross margin scenario, the consumer water heater industry *recovers* conversion costs incurred as a result of amended standards. The approach used in the microwave ovens rulemaking (*i.e.*, a conversion cost recovery scenario) modeled a scenario in which manufacturers recover investments through an increase in their manufacturer markup. 88 FR 39912, 39935. DOE implemented this scenario in the microwave ovens GRIM by calibrating the standards case manufacturer markups for each product class at each efficiency level to cause manufacturer INPV in the standards cases to be equal to the INPV in the no-new-standards case. Thus, if DOE applied a conversion cost recovery scenario in this rulemaking, the potential change in INPV at the adopted TSL would be within the range of estimated impacts resulting from the preservation of gross margin scenario and preservation of operating profit scenario. As such, DOE maintained the two standards-case manufacturer markup scenarios used in the July 2023 NOPR for this final rule as they most appropriately reflect the upper (least severe) and lower (more severe) impacts to manufacturer profitability under amended standards.

b. Cumulative Regulatory Burden

In response to the July 2023 NOPR, AHRI submitted written comments regarding cumulative regulatory burden. AHRI urged DOE to consider the high volume of regulatory activity that directly affects manufacturers of consumer water heaters and expressed concern that DOE was rushing to publish recent rulemakings, risking significant revision that will prolong uncertainty, confuse consumers, and potentially undermine broader policy goals. AHRI cited standards and test procedure rulemakings in regards not only to consumer water heaters, but also to consumer boilers, consumer pool heaters, a final rule pertaining to standards for commercial water heaters, small electric motors, commercial and industrial pumps, commercial and multifamily high-rise and low-rise residential, as well as low and zero NOx actions by California Air Resources Board ("CARB") and individual air quality management districts, State building code changes, ENERGY STAR potentially setting a max-tech requirement for gas storage water heaters, and Federal and State refrigerant regulations as regulatory actions that impact consumer water heater manufacturers. (AHRI, No. 1167 at pp. 7-9)

In response to the July 2023 NOPR, BWC commented that the impact of cumulative regulatory burden experienced by manufacturers is not limited to conversion costs, but also to the preparations manufacturers must undergo in order to respond to proposed rules. BWC further stated that DOE has promulgated several major rulemakings that will directly impact the products that BWC manufactures, in addition to actions undertaken by other governments and programs, and that the ability of manufacturers to draw on outside resources for assistance will be severely limited by the concurrent needs of many manufacturers across rulemakings, particularly in the case of third-party laboratories. BWC stated that due to the burden this rulemaking will place on third-party labs, as well as the general burden of multiple concurrent ongoing regulatory actions, BWC strongly disagreed with DOE's decision not to consider test rulemakings as part of its analysis. (BWC, No. 1164 at pp. 24-26) BWC also stated that, due to concurrent regulatory actions regarding energy efficiency at both the State and Federal levels, it disagreed with DOE's conclusion in section VI.B.5 of the July 2023 NOPR that there are no rules or regulations that duplicate, overlap, or conflict with this proposed rule and encouraged DOE to account for all of these issues, ideally allowing manufacturers more time to review and respond to DOE rulemakings when requested. (BWC, No. 1164 at p. 24)

DOE analyzes cumulative regulatory burden pursuant to section 13(g) of Appendix A. 10 CFR part 430, subpart C, appendix A, section 13(g); 10 CFR 431.4. DOE notes some of the rules (*e.g.*, consumer boilers) detailed by AHRI are not finalized.

Regulations that are not yet finalized are not considered as cumulative regulatory burden, as the timing, cost, and impacts of unfinalized rules are speculative. However, to aid stakeholders in identifying potential cumulative regulatory burden, DOE does list rulemakings that have proposed rules, which have tentative compliance dates, compliance levels, and compliance cost estimates. The results of this analysis can be found in section V.B.2.e of this document. As shown in Table V.21, DOE analyzed the consumer boilers, consumer pool heaters, and commercial water heaters rulemakings as part of its cumulative regulatory burden analysis. Regarding small electric motors, DOE published a notice of proposed determination ("NOPD") on February 6, 2023. As such, DOE would not consider the small electric motors rulemaking as contributing to cumulative regulatory burden since DOE did not propose to amend its energy conservation standards. 88 FR 7629. Regarding commercial and industrial pumps, DOE similarly would not consider the commercial and industrial pumps rulemaking as contributing to cumulative regulatory burden since DOE did not propose to amend its energy conservations standards.

Regarding AHRI's comment about ultra-low NOx and zero NOx regulations, DOE notes that in its analysis of cumulative regulatory burden, DOE considers Federal, product specific regulations that have compliance dates within 3 years of one another. DOE is not aware of any Federal or State ultra-low NOx or zero NOx regulations specific to consumer water heaters with compliance dates within the 7-year cumulative regulatory burden timeframe (2027–2033).[159] DOE notes that certain localities (*i.e.*, California Air

[159] California Air Resources Board ("CARB") has stated that it is committed to explore developing and proposing zero-emission GHG standards for new space and water heaters sold in California as part of the

Districts) have adopted regulations requiring ultra-low NOx consumer water heaters. DOE accounts for the portion of ultra-low NOx shipments in its analysis. DOE notes that a California Air District–the Bay Area Air Quality Management District Board of Directors–has adopted amendments to eliminate NOx emissions from certain gas-fired consumer water heaters beginning in 2027.[160] There are currently no natural gas-fired water heaters on the market that would meet the zero NOx standards, though manufacturers may choose to develop them. Regarding building code changes in states requiring heat pump water heating, DOE's accounts for increased incentives for higher efficiency equipment and electrification efforts in its shipments analysis. *See* section IV.H.1 of this document for additional information on product efficiency trends.

Regarding Federal and State refrigerant regulations, EPA published a final rule pertaining to the phaseout of HFC refrigerants with high global warming potential ("GWP") in specific sectors or subsectors on October 24, 2023. 88 FR 73098. However, EPA does not adopt provisions to limit the manufacture of heat pump water heaters with HFC refrigerants in that final rule. EPA restricts the use of HFCs and blends containing HFCs with a GWP of 150 or greater beginning January 1, 2025 for all foam subsectors, including rigid polyurethane for use in water heaters. As discussed in chapter 3 of the final rule TSD, DOE found that water heater manufacturers have already begun transitioning to alternative blowing agents for insulation foam. Additionally, DOE notes

2022 State Strategy for the State Implementation Plan adopted in September 2022. However, at the time of issuance, CARB has not proposed or adopted such standards for consumer water heaters. Additional information is available at: *ww2.arb.ca.gov/our-work/programs/zero-emission-appliance-standards/about*. (Last accessed Nov. 29, 2023).

[160] Available at: *www.baaqmd.gov/~/media/dotgov/files/rules/reg-9-rule-4-nitrogen-oxides-from-fan-type-residential-central-furnaces/2021-amendments/documents/20230315_rg0906-pdf.pdf?rev=436fcdb037324b0b8f0c981d869e684d&sc_lang=en*

that the January 1, 2025 compliance date falls outside the cumulative regulatory burden timeframe. Regarding the comments about EPA's new ENERGY STAR levels, DOE notes that participating in ENERGY STAR is voluntary and not considered in DOE's analysis of cumulative regulatory burden.

Regarding BWC's request that DOE not discount the costs for stakeholders to review rulemakings, although appreciative that monitoring and responding to rulemakings does impose costs for stakeholders, DOE believes that this is outside the scope of analysis for individual product rulemakings. Because EPCA requires DOE to establish and maintain the energy conservation program for consumer products and to periodically propose new and amended standards (or propose that standards for products do not need to be amended) and test procedures, DOE considers this rulemaking activity to be part of the analytical baseline (*i.e.*, in the no-new-standards case and the standards case). That is, these activities (*e.g.*, reviewing proposed rules or proposed determinations) would exist regardless of the regulatory option that DOE adopts through a rulemaking and would be independent from the conversion costs required to adapt product designs and manufacturing facilitates to meet an amended standard.

c. Manufacturing Capacity

A.O. Smith noted that while it supports the intent of DOE's proposal to move the minimum energy conservation standards for a subset of consumer water heaters, A.O. Smith remains concerned with the feasibility of implementing these dramatic shifts in the time frame proposed. A.O. Smith commented that the July 2023 NOPR would drive an unprecedented transformation for the water heater industry, impacting manufacturers, its supply chain, distributors, plumbers, and installers. A.O. Smith noted that it invested significant capital in its heat pump manufacturing facility following the April 2010 Final Rule in anticipation of a ramp up in demand, which did not materialize. A.O. Smith noted it plans to make the necessary investments to transition to heat pump water heaters, but expressed concern that uncertainty in the market may place these investments at risk. A.O. Smith further expressed concern about the availability of the necessary components at the scale the July 2023 NOPR would require, as well as the current shortage of workers with the necessary skills and experience to manufacture heat pump water heaters. (A.O. Smith, No. 1182 at pp. 17–19) Gas Association Commenters questioned the realism of ramping up heat pump water heater capacity, stating that DOE did not provide sufficient analysis showing how manufacturers could produce an additional 3 to 4 million electric heat pump water heaters per year. (Gas Association Commenters, No. 1181 at p. 33)

Rheem commented it is committed to transitioning the majority of its electric storage water heaters to heat pump water heaters within the 5-year compliance period, which Rheem views as sufficiently long to complete the conversion. Rheem recommended that DOE and other Federal agencies promote awareness of this rulemaking and the future of water heating in the United States, particularly among plumbers, contractors, and consumers. (Rheem, No. 1177 at p. 10)

DOE recognizes that the standards proposed in the July 2023 NOPR and adopted in this final rule would require investments to update production facilities and redesign products. DOE accounts for product and capital conversion costs in the MIA. *See* section IV.J.2.c of this document. Regarding industry's ability to ramp up production within the 5-year compliance period, DOE believes that having a major manufacturer sign on to the Joint Stakeholder Recommendation is a testament to industry's ability to ramp up capacity to produce the volumes necessary to support the heat pump water heater market that will be required by TSL 2 by the compliance date of the amended standards. Regarding the uncertainty in the market related to heat pump water heaters, DOE recognizes that amended standards could lead to shifts in the market towards smaller electric storage water heater sizes which can meet the adopted standard levels without the use of heat pump technology. DOE accounts for the potential market shift in its shipments analysis, a key input to the GRIM. For this final rule, DOE assumes a portion of consumers would select one or more smaller electric storage water heaters with or without a "booster" instantaneous water heater instead of replacing a larger electric storage water heater with a heat pump water heater under amended standards, *see* IV.G.1 of this document for additional details. DOE notes that measures such as requiring high-temperature testing will be required for certain electric storage water heaters. As discussed in section V.D.1 of this document, the use of high-temperature testing will be required for small electric resistance water heaters that are able to continuously store water at a higher temperature than the delivered water temperature setpoint since DOE expects that consumers will use the high-temperature mode as part of the regular operation of their water heater. By implementing the high-temperature test method for certain smaller electric storage water heaters designed to compete with larger electric storage water heaters by operating at a higher temperature, DOE will ensure that representations for such products are accurate and provide consumers with the means to directly compare these products to the larger water heaters they will likely compete with. In other words, the high-temperature test method would create an equivalent basis of comparison for products which can offer the same effective storage capacity. *See* section V.D.1 of this document for information on high-temperature testing.

K. Emissions Analysis

The emissions analysis consists of two components. The first component estimates the effect of potential energy conservation standards on power sector and site (where applicable) combustion emissions of CO_2, NO_X, SO_2, and Hg. The second component estimates the impacts of potential standards on emissions of two additional greenhouse gases, CH_4 and N_2O, as well as the reductions in emissions of other gases due to "upstream" activities in the fuel production chain. These upstream activities comprise extraction, processing, and transporting fuels to the site of combustion.

The analysis of electric power sector emissions of CO_2, NO_X, SO_2, and Hg uses emissions intended to represent the marginal impacts of the change in electricity consumption associated with amended or new standards. The methodology is based on results published for the *AEO*, including a set of side cases that implement a variety of efficiency-related policies. The methodology is described in appendix 13A in the final rule TSD. The analysis presented in this notice uses projections from *AEO2023*. Power sector emissions of CH_4 and N_2O from fuel combustion are estimated using Emission Factors for Greenhouse Gas Inventories published by the EPA.[161]

The on-site operation of consumer water heaters involves combustion of fossil fuels and results in emissions of CO_2, NO_X, SO_2, CH_4, and N_2O where these products are

[161] Available at *www.epa.gov/sites/production/files/2021-04/documents/emission-factors_apr2021.pdf* (last accessed Dec. 1, 2023).

used. Site emissions of these gases were estimated using Emission Factors for Greenhouse Gas Inventories and, for NO_X and SO_2, emissions intensity factors from an EPA publication.[162]

FFC upstream emissions, which include emissions from fuel combustion during extraction, processing, and transportation of fuels, and "fugitive" emissions (direct leakage to the atmosphere) of CH_4 and CO_2, are estimated based on the methodology described in chapter 15 of the final rule TSD.

The emissions intensity factors are expressed in terms of physical units per MWh or MMBtu of site energy savings. For power sector emissions, specific emissions intensity factors are calculated by sector and end use. Total emissions reductions are estimated using the energy savings calculated in the national impact analysis.

BWC recommended including emissions as a result of increased manufacturing of parts at a higher standard level, such as compressors, evaporators, and other parts for heat pump water heaters. Additionally, BWC mentioned that the leaking of refrigerant in heat pump water heaters may result in additional unaccounted-for emissions and BWC is discouraged that DOE has already declined to take the emission from refrigerant leakages into account in the Energy Conservation Standards for Consumer Pool Heater Final Rule. BWC commented that ASHRAE standards are in development to measure refrigerant

[162] U.S. Environmental Protection Agency. External Combustion Sources. In *Compilation of Air Pollutant Emission Factors*. AP-42. Fifth Edition. Volume I: Stationary Point and Area Sources. Chapter 1. Available at *www.epa.gov/air-emissions-factors-and-quantification/ap-42-compilation-air-emissions-factors#Proposed/* (last accessed July 12, 2021).

leakage expectations for heat pump products that could be leveraged in future DOE analysis. (BWC No. 1164 at p. 5)

DOE's emissions analysis is guided by section 16.h of Appendix A[163], which states that DOE calculates emissions reductions of carbon dioxide, sulfur dioxide, nitrogen oxides, methane, nitrous oxides, and mercury likely to be avoided based on an analysis that includes specific components. These components only include direct emissions from use of covered products and emissions in the full-fuel-cycle. DOE has never considered air pollutant emissions associated with manufacturing or transport of products or emissions of refrigerants. Even if DOE considered the emissions from refrigerants, DOE estimates that refrigerant leakages in heat pump water heaters will be rare and can be prevented with regular inspection and repair, which DOE accounts for as repair and maintenance costs in its LCC analysis. If refrigerant leaks do occur, the associated emissions increase would still be negligible compared to the emissions savings of this rule. Accounting for refrigerant leakage would not change the economic justification of the rule.

1. Air Quality Regulations Incorporated in DOE's Analysis

DOE's no-new-standards case for the electric power sector reflects the *AEO*, which incorporates the projected impacts of existing air quality regulations on emissions. *AEO2023* reflects, to the extent possible, laws and regulations adopted through mid-November 2022, including the emissions control programs discussed in the following

[163] Appendix A to Subpart C of Part 430—Procedures, Interpretations, and Policies for Consideration of New or Revised Energy Conservation Standards and Test Procedures for Consumer Products and Certain Commercial/Industrial Equipment. https://www.ecfr.gov/current/title-10/chapter-II/subchapter-D/part-430/subpart-C/appendix-Appendix%20A%20to%20Subpart%20C%20of%20Part%20430

paragraphs the emissions control programs discussed in the following paragraphs, and the Inflation Reduction Act.[164]

SO_2 emissions from affected electric generating units ("EGUs") are subject to nationwide and regional emissions cap-and-trade programs. Title IV of the Clean Air Act sets an annual emissions cap on SO_2 for affected EGUs in the 48 contiguous States and the District of Columbia ("D.C."). (42 U.S.C. 7651 *et seq.*) SO_2 emissions from numerous States in the eastern half of the United States are also limited under the Cross-State Air Pollution Rule ("CSAPR"). 76 FR 48208 (Aug. 8, 2011). CSAPR requires these States to reduce certain emissions, including annual SO_2 emissions, and went into effect as of January 1, 2015.[165] The *AEO* incorporates implementation of CSAPR, including the update to the CSAPR ozone season program emission budgets and target dates issued in 2016. 81 FR 74504 (Oct. 26, 2016). Compliance with CSAPR is flexible among EGUs and is enforced through the use of tradable emissions allowances. Under existing EPA regulations, for states subject to SO_2 emissions limits under CSAPR, any excess SO_2 emissions allowances resulting from the lower electricity demand caused by the adoption of an efficiency standard could be used to permit offsetting increases in SO_2 emissions by another regulated EGU.

[164] For further information, see the Assumptions to *AEO2023* report that sets forth the major assumptions used to generate the projections in the Annual Energy Outlook. Available at *www.eia.gov/outlooks/aeo/assumptions/* (last accessed Dec. 1, 2023).

[165] CSAPR requires States to address annual emissions of SO_2 and NO_X, precursors to the formation of fine particulate matter ("$PM_{2.5}$") pollution, in order to address the interstate transport of pollution with respect to the 1997 and 2006 $PM_{2.5}$ National Ambient Air Quality Standards ("NAAQS"). CSAPR also requires certain States to address the ozone season (May-Sept.) emissions of NO_X, a precursor to the formation of ozone pollution, in order to address the interstate transport of ozone pollution with respect to the 1997 ozone NAAQS. 76 FR 48208 (Aug. 8, 2011). EPA subsequently issued a supplemental rule that included an additional five States in the CSAPR ozone season program; 76 FR 80760 (Dec. 27, 2011) (Supplemental Rule), and EPA issued the CSAPR Update for the 2008 ozone NAAQS. 81 FR 74504 (Oct. 26, 2016).

However, beginning in 2016, SO_2 emissions began to fall as a result of the Mercury and Air Toxics Standards ("MATS") for power plants.[166] 77 FR 9304 (Feb. 16, 2012). The final rule establishes power plant emission standards for mercury, acid gases, and non-mercury metallic toxic pollutants. Because of the emissions reductions under the MATS, it is unlikely that excess SO_2 emissions allowances resulting from the lower electricity demand would be needed or used to permit offsetting increases in SO_2 emissions by another regulated EGU. Therefore, energy conservation standards that decrease electricity generation will generally reduce SO_2 emissions. DOE estimated SO_2 emissions reduction using emissions factors based on *AEO2023.*

CSAPR also established limits on NO_X emissions for numerous States in the eastern half of the United States. Energy conservation standards would have little effect on NO_X emissions in those States covered by CSAPR emissions limits if excess NO_X emissions allowances resulting from the lower electricity demand could be used to permit offsetting increases in NO_X emissions from other EGUs. In such case, NOx emissions would remain near the limit even if electricity generation goes down. Depending on the configuration of the power sector in the different regions and the need for allowances, however, NO_X emissions might not remain at the limit in the case of lower electricity demand. That would mean that standards might reduce NOx emissions in covered States. Despite this possibility, DOE has chosen to be conservative in its analysis and has maintained the assumption that standards will not reduce NO_X emissions in States covered by CSAPR. Standards would be expected to reduce NO_X emissions in the States

[166] In order to continue operating, coal power plants must have either flue gas desulfurization or dry sorbent injection systems installed. Both technologies, which are used to reduce acid gas emissions, also reduce SO_2 emissions.

not covered by CSAPR. DOE used *AEO2023* data to derive NO_X emissions factors for the group of States not covered by CSAPR.

The MATS limit mercury emissions from power plants, but they do not include emissions caps and, as such, DOE's energy conservation standards would be expected to slightly reduce Hg emissions. DOE estimated mercury emissions reduction using emissions factors based on *AEO2023*, which incorporates the MATS.

L. Monetizing Emissions Impacts

As part of the development of this final rule, for the purpose of complying with the requirements of Executive Order 12866, DOE considered the estimated monetary benefits from the reduced emissions of CO_2, CH_4, N_2O, NO_X, and SO_2 that are expected to result from each of the TSLs considered. In order to make this calculation analogous to the calculation of the NPV of consumer benefit, DOE considered the reduced emissions expected to result over the lifetime of products shipped in the projection period for each TSL. This section summarizes the basis for the values used for monetizing the emissions benefits and presents the values considered in this final rule.

To monetize the benefits of reducing GHG emissions, this analysis uses the interim estimates presented in the *Technical Support Document: Social Cost of Carbon, Methane, and Nitrous Oxide Interim Estimates Under Executive Order 13990* published in February 2021 by the IWG.

1. Monetization of Greenhouse Gas Emissions

DOE estimates the monetized benefits of the reductions in emissions of CO_2, CH_4, and N_2O by using a measure of the SC ("SC") of each pollutant (e.g., SC-CO_2). These estimates represent the monetary value of the net harm to society associated with a marginal increase in emissions of these pollutants in a given year, or the benefit of avoiding that increase. These estimates are intended to include (but are not limited to) climate-change-related changes in net agricultural productivity, human health, property damages from increased flood risk, disruption of energy systems, risk of conflict, environmental migration, and the value of ecosystem services.

DOE exercises its own judgment in presenting monetized climate benefits as recommended by applicable Executive orders, and DOE would reach the same conclusion presented in this rulemaking in the absence of the social cost of greenhouse gases. That is, the social costs of greenhouse gases, whether measured using the February 2021 interim estimates presented by the IWG on the Social Cost of Greenhouse Gases or by another means, did not affect the rule ultimately adopted by DOE.

DOE estimated the global social benefits of CO_2, CH_4, and N_2O reductions using SC-GHG values that were based on the interim values presented in the *Technical Support Document: Social Cost of Carbon, Methane, and Nitrous Oxide Interim Estimates under Executive Order 13990*, published in February 2021 by the IWG ("February 2021 SC-GHG TSD"). The SC-GHG is the monetary value of the net harm to society associated with a marginal increase in emissions in a given year, or the benefit of avoiding that increase. In principle, the SC-GHG includes the value of all climate change impacts, including (but not limited to) changes in net agricultural productivity, human health effects, property damage from increased flood risk and natural disasters, disruption of energy systems, risk of conflict, environmental migration, and the value of ecosystem services. The SC-GHG therefore, reflects the societal value of reducing emissions of the gas in question by one metric ton. The SC-GHG is the theoretically appropriate value to use in conducting benefit-cost analyses of policies that affect CO_2, N_2O and CH4 emissions.

As a member of the IWG involved in the development of the February 2021 SC-GHG TSD, DOE agreed that the interim SC-GHG estimates represent the most appropriate estimate of the SC-GHG until revised estimates are developed reflecting the latest, peer-reviewed science. *See* 87 FR 78382, 78406-78408 for discussion of the development and details of the IWG SC-GHG estimates.

There are a number of limitations and uncertainties associated with the SC-GHG estimates. First, the current scientific and economic understanding of discounting approaches suggests discount rates appropriate for intergenerational analysis in the context of climate change are likely to be less than 3 percent, near 2 percent or lower.[167] Second, the IAMs used to produce these interim estimates do not include all of the important physical, ecological, and economic impacts of climate change recognized in the climate change literature and the science underlying their "damage functions"—*i.e.*, the core parts of the IAMs that map global mean temperature changes and other physical

[167] Interagency Working Group on Social Cost of Greenhouse Gases. 2021. Technical Support Document: Social Cost of Carbon, Methane, and Nitrous Oxide Interim Estimates under Executive Order 13990. February. United States Government. Available at *www.whitehouse.gov/briefing-room/blog/2021/02/26/a-return-to-science-evidence-based-estimates-of-the-benefits-of-reducing-climate-pollution/*.

impacts of climate change into economic (both market and nonmarket) damages—lags behind the most recent research. For example, limitations include the incomplete treatment of catastrophic and non-catastrophic impacts in the integrated assessment models, their incomplete treatment of adaptation and technological change, the incomplete way in which inter-regional and intersectoral linkages are modeled, uncertainty in the extrapolation of damages to high temperatures, and inadequate representation of the relationship between the discount rate and uncertainty in economic growth over long time horizons. Likewise, the socioeconomic and emissions scenarios used as inputs to the models do not reflect new information from the last decade of scenario generation or the full range of projections. The modeling limitations do not all work in the same direction in terms of their influence on the SC-CO_2 estimates. However, as discussed in the February 2021 SC-GHG TSD, the IWG has recommended that, taken together, the limitations suggest that the interim SC-GHG estimates used in this final rule likely underestimate the damages from GHG emissions. DOE concurs with this assessment.

DOE's derivations of the SC-CO_2, SC-N_2O, and SC-CH_4 values used for this final rule are discussed in the following sections, and the results of DOE's analyses estimating the benefits of the reductions in emissions of these GHGs are presented in section V.B.6 of this document.

The Attorney General of TN asserted that the standards improperly rely on faulty social-cost-of-carbon estimate. (Attorney General of TN, No. 1149 at p. 2) In response, DOE noted that the Interagency Working Group’s (IWG) Social Costs of Greenhouse Gas (SC-GHG) estimates were developed over many years, using transparent process, peer-reviewed methodologies, the best science available at the time of that process, and with input from the public. The IWG's 2016 TSD[168] and the 2017 National Academies report provide detailed discussions of the ways in which the modeling underlying the development of the SC-GHG estimates addressed quantified sources of uncertainty.[169] In the February 2021 SC-GHG TSD, the IWG stated that the models used to produce the interim estimates do not include all of the important physical, ecological, and economic impacts of climate change recognized in the climate change literature. In the judgment of the IWG, these and other limitations suggest that the range of four interim SC-GHG estimates presented in the TSD likely underestimate societal damages from GHG emissions.

DOE is aware that in December 2023, EPA issued a new set of SC-GHG estimates in connection with a final rulemaking under the Clean Air Act. [170] As DOE had used the IWG interim values in proposing this rule and is currently reviewing the updated 2023 SC-GHG values, for this final rule, DOE used these updated 2023 SC-GHG values to conduct a sensitivity analysis of the value of GHG emissions reductions. DOE notes that because EPA's estimates are considerably higher than the IWG's interim SC-GHG values applied for this final rule, an analysis that uses the EPA's estimates results in significantly greater climate-related benefits. However, such results would not affect DOE's decision in this final rule. As stated elsewhere in this document, DOE would

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168 Interagency Working Group on Social Cost of Greenhouse Gases, United States Government. Technical Update on the Social Cost of Carbon for Regulatory Impact Analysis Under Executive Order 12866. August 2016. (Last accessed January 18, 2022.) *www.epa.gov/sites/default/files/2016-12/documents/sc_co2_tsd_august_2016.pdf*;

169 An overview is presented in section 4.1 of the February 2021 SC-GHG TSD.

170 See www.epa.gov/environmental-economics/scghg.

reach the same conclusion regarding the economic justification of the standards presented in this final rule without considering the IWG's interim SC-GHG values, which DOE agrees are conservative estimates. For the same reason, if DOE were to use EPA's higher SC-GHG estimates, they would not change DOE's conclusion that the standards are economically justified.

a. Social Cost of Carbon

The SC-CO_2 values used for this final rule were based on the values developed for the February 2021 SC-GHG TSD, which are shown in Table IV.30 in 5-year increments from 2020 to 2050. The set of annual values that DOE used, which was adapted from estimates published by EPA,[171] is presented in appendix 14A of the final rule TSD. These estimates are based on methods, assumptions, and parameters identical to the estimates published by the IWG (which were based on EPA modeling) and include values for 2051 to 2070. DOE expects additional climate benefits to accrue for products still operating after 2070, but a lack of available SC-CO_2 estimates for emissions years beyond 2070 prevents DOE from monetizing these potential benefits in this analysis.

[171] *See* EPA, *Revised 2023 and Later Model Year Light-Duty Vehicle GHG Emissions Standards: Regulatory Impact Analysis*, Washington, D.C., December 2021. Available at *nepis.epa.gov/Exe/ZyPDF.cgi?Dockey=P1013ORN.pdf* (last accessed Dec. 1, 2023).

Table IV.30. Annual SC-CO_2 Values from 2021 Interagency Update, 2020–2050 (2020$ per Metric Ton CO_2)

Year	Discount Rate and Statistic			
	5%	3%	2.5%	3%
	Average	Average	Average	95th percentile
2020	14	51	76	152
2025	17	56	83	169
2030	19	62	89	187
2035	22	67	96	206
2040	25	73	103	225
2045	28	79	110	242
2050	32	85	116	260

DOE multiplied the CO_2 emissions reduction estimated for each year by the SC-CO_2 value for that year in each of the four cases. DOE adjusted the values to 2022$ using the implicit price deflator for gross domestic product ("GDP") from the Bureau of Economic Analysis. To calculate a present value of the stream of monetary values, DOE discounted the values in each of the four cases using the specific discount rate that had been used to obtain the SC-CO_2 values in each case.

b. Social Cost of Methane and Nitrous Oxide

The SC-CH_4 and SC-N_2O values used for this final rule were based on the values developed for the February 2021 SC-GHG TSD. Table IV.31 shows the updated sets of SC-CH_4 and SC- N_2O estimates from the latest interagency update in 5-year increments from 2020 to 2050. The full set of annual values used is presented in appendix 14A of the final rule TSD. To capture the uncertainties involved in regulatory impact analysis, DOE has determined it is appropriate to include all four sets of SC-CH_4 and SC- N_2O values, as recommended by the IWG. DOE derived values after 2050 using the approach described above for the SC-CO_2.

Table IV.31. Annual SC-CH_4 and SC-N_2O Values from 2021 Interagency Update, 2020–2050 (2020$ per Metric Ton)

Year	SC-CH_4				SC-N_2O			
	Discount Rate and Statistic				Discount Rate and Statistic			
	5%	3%	2.5%	3%	5%	3%	2.5 %	3%
	Average	Average	Average	95th percentile	Average	Average	Average	95th percentile
2020	670	1500	2000	3900	5800	18000	27000	48000
2025	800	1700	2200	4500	6800	21000	30000	54000
2030	940	2000	2500	5200	7800	23000	33000	60000
2035	1100	2200	2800	6000	9000	25000	36000	67000
2040	1300	2500	3100	6700	10000	28000	39000	74000
2045	1500	2800	3500	7500	12000	30000	42000	81000
2050	1700	3100	3800	8200	13000	33000	45000	88000

DOE multiplied the CH_4 and N_2O emissions reduction estimated for each year by the SC-CH_4 and SC-N_2O estimates for that year in each of the cases. DOE adjusted the values to 2022$ using the implicit price deflator for gross domestic product ("GDP") from the Bureau of Economic Analysis. To calculate a present value of the stream of monetary values, DOE discounted the values in each of the cases using the specific discount rate that had been used to obtain the SC-CH_4 and SC-N_2O estimates in each case.

c. Sensitivity Analysis Using Updated SC-GHG Estimates

In December 2023, EPA issued an updated set of SC-GHG estimates (2023 SC-GHG) in connection with a final rulemaking under the Clean Air Act.[172] These estimates incorporate recent research and address recommendations of the National Academies (2017) and comments from a 2023 external peer review of the accompanying technical report. For this rulemaking, DOE used these updated 2023 SC-GHG values to conduct a sensitivity analysis of the value of GHG emissions reductions associated with alternative

[172] *See www.epa.gov/environmental-economics/scghg.*

standards for consumer water heaters. This sensitivity analysis provides an expanded range of potential climate benefits associated with amended standards. The final year of EPA's new 2023 SC-GHG estimates is 2080; therefore, DOE did not monetize the climate benefits of GHG emissions reductions occurring after 2080.

The overall climate benefits are greater when using the higher, updated 2023 SC-GHG estimates, compared to the climate benefits using the older IWG SC-GHG estimates. The results of the sensitivity analysis are presented in appendix 14C of the final rule TSD.

2. Monetization of Other Emissions Impacts

For the final rule, DOE estimated the monetized value of NO_X and SO_2 emissions reductions from electricity generation using benefit-per-ton estimates for that sector from the EPA's Benefits Mapping and Analysis Program.[173] DOE used EPA's values for $PM_{2.5}$-related benefits associated with NO_X and SO_2 and for ozone-related benefits associated with NO_X for 2025 and 2030, and 2040, calculated with discount rates of 3 percent and 7 percent. DOE used linear interpolation to define values for the years not given in the 2025 to 2040 period; for years beyond 2040, the values are held constant. DOE combined the EPA regional benefit-per-ton estimates with regional information on electricity consumption and emissions from *AEO2023* to define weighted-average national values for NO_X and SO_2 (*see* appendix 14B of the final rule TSD).

[173] U.S. Environmental Protection Agency. *Estimating the Benefit per Ton of Reducing Directly-Emitted PM2.5, PM2.5 Precursors and Ozone Precursors from 21 Sectors*. Available at *www.epa.gov/benmap/estimating-benefit-ton-reducing-directly-emitted-pm25-pm25-precursors-and-ozone-precursors* (last accessed Dec. 1, 2023

DOE also estimated the monetized value of NO_X and SO_2 emissions reductions from site use of natural gas in consumer water heaters using benefit per ton estimates from the EPA's Benefits Mapping and Analysis Program. Although none of the sectors covered by EPA refers specifically to residential and commercial buildings, the sector called "area sources" would be a reasonable proxy for residential and commercial buildings.[174] The EPA document provides high and low estimates for 2025 and 2030 at 3- and 7-percent discount rates.[175] DOE used the same linear interpolation and extrapolation as it did with the values for electricity generation.

DOE multiplied the site emissions reduction (in tons) in each year by the associated $/ton values, and then discounted each series using discount rates of 3 percent and 7 percent as appropriate.

M. Utility Impact Analysis

The utility impact analysis estimates the changes in installed electrical capacity and generation projected to result for each considered TSL. The analysis is based on published output from the NEMS associated with *AEO2023*. NEMS produces the *AEO* Reference case, as well as a number of side cases that estimate the economy-wide impacts of changes to energy supply and demand. For the current analysis, impacts are quantified by comparing the levels of electricity sector generation, installed capacity, fuel consumption and emissions in the *AEO2023* Reference case and various side cases.

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[174] "Area sources" represents all emission sources for which states do not have exact (point) locations in their emissions inventories. Because exact locations would tend to be associated with larger sources, "area sources" would be fairly representative of small dispersed sources like homes and businesses.
[175] "Area sources" are a category in the 2018 document from EPA but are not used in the 2021 document cited above. *See*: *www.epa.gov/sites/default/files/2018-02/documents/sourceapportionmentbpttsd_2018*.pdf.

Details of the methodology are provided in the appendices to chapter 15 of the final rule TSD.

The output of this analysis is a set of time-dependent coefficients that capture the change in electricity generation, primary fuel consumption, installed capacity and power sector emissions due to a unit reduction in demand for a given end use. These coefficients are multiplied by the stream of electricity savings calculated in the NIA to provide estimates of selected utility impacts of potential new or amended energy conservation standards. The utility analysis also estimates the impact on gas utilities in terms of projected changes in natural gas deliveries to consumers for each TSL.

N. Employment Impact Analysis

DOE considers employment impacts in the domestic economy as one factor in selecting a standard. Employment impacts from new or amended energy conservation standards include both direct and indirect impacts. Direct employment impacts are any changes in the number of employees of manufacturers of the products subject to standards. The MIA addresses those impacts. Indirect employment impacts are changes in national employment that occur due to the shift in expenditures and capital investment caused by the purchase and operation of more-efficient appliances. Indirect employment impacts from standards consist of the net jobs created or eliminated in the national economy, other than in the manufacturing sector being regulated, caused by (1) reduced spending by consumers on energy, (2) reduced spending on new energy supply by the utility industry, (3) increased consumer spending on the products to which the new standards apply and other goods and services, and (4) the effects of those three factors throughout the economy.

One method for assessing the possible effects on the demand for labor of such shifts in economic activity is to compare sector employment statistics developed by the Labor Department's Bureau of Labor Statistics ("BLS"). BLS regularly publishes its estimates of the number of jobs per million dollars of economic activity in different sectors of the economy, as well as the jobs created elsewhere in the economy by this same economic activity. Data from BLS indicate that expenditures in the utility sector generally create fewer jobs (both directly and indirectly) than expenditures in other sectors of the economy.[176] There are many reasons for these differences, including wage differences and the fact that the utility sector is more capital-intensive and less labor-intensive than other sectors. Energy conservation standards have the effect of reducing consumer utility bills. Because reduced consumer expenditures for energy likely lead to increased expenditures in other sectors of the economy, the general effect of efficiency standards is to shift economic activity from a less labor-intensive sector (*i.e.*, the utility sector) to more labor-intensive sectors (*e.g.*, the retail and service sectors). Thus, the BLS data suggest that net national employment may increase due to shifts in economic activity resulting from energy conservation standards.

DOE estimated indirect national employment impacts for the standard levels considered in this final rule using an input/output model of the U.S. economy called

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[176] *See* U.S. Department of Commerce–Bureau of Economic Analysis. *Regional Input-Output Modeling System (RIMS II) User's Guide*. Available at: *www.bea.gov/resources/methodologies/RIMSII-user-guide* (last accessed Jan. 18, 2024).

Impact of Sector Energy Technologies version 4 ("ImSET").[177] ImSET is a special-purpose version of the "U.S. Benchmark National Input-Output" ("I-O") model, which was designed to estimate the national employment and income effects of energy-saving technologies. The ImSET software includes a computer- based I-O model having structural coefficients that characterize economic flows among 187 sectors most relevant to industrial, commercial, and residential building energy use.

DOE notes that ImSET is not a general equilibrium forecasting model, and that there are uncertainties involved in projecting employment impacts, especially changes in the later years of the analysis. Because ImSET does not incorporate price changes, the employment effects predicted by ImSET may over-estimate actual job impacts over the long run for this rule. Therefore, DOE used ImSET only to generate results for near-term timeframes (2030–2034), where these uncertainties are reduced. For more details on the employment impact analysis, see chapter 16 of the final rule TSD.

V. Analytical Results and Conclusions

The following section addresses the results from DOE's analyses with respect to the considered energy conservation standards for consumer water heaters. It addresses the TSLs examined by DOE, the projected impacts of each of these levels if adopted as energy conservation standards for consumer water heaters, and the standards levels that

[177] Livingston, O. V., S. R. Bender, M. J. Scott, and R. W. Schultz. *ImSET 4.0: Impact of Sector Energy Technologies Model Description and User's Guide*. 2015. Pacific Northwest National Laboratory: Richland, WA. PNNL-24563.

DOE is adopting in this final rule. Additional details regarding DOE's analyses are contained in the final rule TSD supporting this document.

A. Trial Standard Levels

In general, DOE typically evaluates potential new or amended standards for products and equipment by grouping individual efficiency levels for each class into TSLs. Use of TSLs allows DOE to identify and consider manufacturer cost interactions between the product classes, to the extent that there are such interactions, and price elasticity of consumer purchasing decisions that may change when different standard levels are set. The changes to the shipments model will drive differential national impacts both on the consumer and manufacturer side that are more realistic of how the market may change in response to amended DOE standards.

In the analysis conducted for this final rule, DOE analyzed the benefits and burdens of six TSLs for consumer water heaters. DOE developed TSLs that combine efficiency levels for each analyzed product class. DOE presents the results for the TSLs in this document, while the results for all efficiency levels that DOE analyzed are in the final rule TSD.

Table V.1 presents the TSLs and the corresponding efficiency levels that DOE has identified for potential amended energy conservation standards for consumer water heaters. TSL 6 represents the maximum technologically feasible ("max-tech") energy efficiency for all product classes. TSL 5 represents the highest efficiency level for each product class with a positive NPV at the 7-percent discount rate for all product classes. For gas-fired gas storage water heater, the NPV at the 7-percent discount rate is negative from EL 3 to EL 5. Therefore, TSL 5 is constructed by reducing the efficiency level for gas-fired storage water heaters (*i.e.*, EL 2) and with the same efficiency level for all other product classes compared to the max-tech. TSL 4 represents the highest efficiency level for each product class with the maximum NPV at the 7-percent discount rate for all product classes. Therefore, TSL 4 is constructed by reducing the efficiency level for electric storage water heaters (*i.e.*, EL 2). TSL 3 represents an interim energy efficiency level between the Joint Stakeholder Recommendation (*i.e.*, TSL 2) and TSL 4. TSL 2 represents the Joint Stakeholder Recommendation. Finally, because EL 1 is the lowest analyzed efficiency level above baseline, TSL 1 is constructed with EL 1 for all product classes, except for electric storage water heaters (20 gal ≤ V_{eff} ≤ 55 gal) which is set equal to the current standard level.

Table V.1 Trial Standard Levels for Consumer Water Heaters

Product Class	Trial Standard Level					
	1	2	3	4	5	6
	Efficiency Level					
Gas-fired Storage Water Heaters (20 gal ≤ V_{eff} ≤ 55 gal)	1	2	2	2	2	5
Oil-fired Storage Water Heaters (V_{eff} ≤ 50 gal)	1	2	2	2	2	2
Small electric storage water heaters (20 gal ≤ V_{eff} ≤ 35 gal and FHR < 51 gal)	0	0	1	1	1	1
Electric Storage Water Heaters (20 gal ≤ V_{eff} ≤ 55 gal, excluding small electric storage water heaters)	0	1	1	2	3	3
Electric Storage Water Heaters (55 gal < V_{eff} ≤ 120 gal)	1	1	1	2	3	3

DOE constructed the TSLs for this final rule to include ELs representative of ELs with similar characteristics (*i.e.*, using similar technologies and/or efficiencies, and having roughly comparable equipment availability). The use of representative ELs provided for greater distinction between the TSLs. While representative ELs were included in the TSLs, DOE considered all efficiency levels as part of its analysis.[178]

B. Economic Justification and Energy Savings

1. Economic Impacts on Individual Consumers

DOE analyzed the economic impacts on consumer water heater consumers by looking at the effects that potential new and amended standards at each TSL would have on the LCC and PBP. DOE also examined the impacts of potential standards on selected consumer subgroups. These analyses are discussed in the following sections.

a. Life-Cycle Cost and Payback Period

In general, higher-efficiency products affect consumers in two ways: (1) purchase price increases and (2) annual operating costs decrease. Inputs used for calculating the LCC and PBP include total installed costs (*i.e.*, product price plus installation costs), and operating costs (*i.e.*, annual energy use, energy prices, energy price trends, repair costs, and maintenance costs). The LCC calculation also uses product lifetime and a discount rate. Chapter 8 of the final rule TSD provides detailed information on the LCC and PBP analyses.

Table V.2 through Table V.11 show the LCC and PBP results for the TSLs considered for each product class. In the first of each pair of tables, the simple payback is measured relative to the baseline product. In the second table, the impacts are

[178] Efficiency levels that were analyzed for this final rule are discussed in section IV.C of this document. Results by efficiency level are presented in TSD chapters 8, 10, and 12.

measured relative to the efficiency distribution in the in the no-new-standards case in the compliance year (see section 00 of this document). Because some consumers purchase products with higher efficiency in the no-new-standards case, the average savings are less than the difference between the average LCC of the baseline product and the average LCC at each TSL. The savings refer only to consumers who are affected by a standard at a given TSL. Those who already purchase a product with efficiency at or above a given TSL are not affected. Consumers for whom the LCC increases at a given TSL experience a net cost.

Table V.2 Average LCC and PBP Results for Gas-fired Storage Water Heaters (20 gal ≤ V_{eff} ≤ 55 gal)

TSL	Efficiency Level	Average Costs *2022$*				Simple Payback *years*	Average Lifetime *years*
		Installed Cost	First Year's Operating Cost	Lifetime Operating Cost	LCC		
0	0	1,432	242	2,868	4,300	NA	14.5
1	1	1,470	237	2,815	4,285	8.4	14.5
2,3,4,5	2	1,578	226	2,689	4,267	9.1	14.5
6	5	2,241	198	2,410	4,651	18.5	14.5

Note: The results for each TSL are calculated assuming that all consumers use products at that efficiency level. The PBP is measured relative to the baseline product.

Table V.3 Average LCC Savings Relative to the No-New-Standards Case for Gas-fired Storage Water Heaters (20 gal ≤ V_{eff} ≤ 55 gal)

TSL	Efficiency Level	Life-Cycle Cost Savings	
		Average LCC Savings* *2022$*	Percent of Consumers that Experience Net Cost
1	1	15	20.3
2,3,4,5	2	29	40.5
6	5	(285)	69.8

* The savings represent the average LCC for affected consumers. Numbers in parentheses denote negative values.

Table V.4 Average LCC and PBP Results for Oil-fired Storage Water Heaters (V_{eff} ≤ 50 gal)

TSL	Efficiency Level	Average Costs *2022$*				Simple Payback *years*	Average Lifetime *years*
		Installed Cost	First Year's Operating Cost	Lifetime Operating Cost	LCC		
0	0	3,934	794	8,441	12,375	NA	15.5
1	1	4,029	773	8,222	12,251	4.7	15.5
2,3,4,5,6	2	4,189	755	8,017	12,206	6.5	15.5

Note: The results for each TSL are calculated assuming that all consumers use products at that efficiency level. The PBP is measured relative to the baseline product.

Table V.5 Average LCC Savings Relative to the No-New-Standards Case for Oil-fired Storage Water Heaters (V_{eff} ≤ 50 gal)

TSL	Efficiency Level	Life-Cycle Cost Savings	
		Average LCC Savings* *2022$*	Percent of Consumers that Experience Net Cost
1	1	123	10.8
2,3,4,5,6	2	141	26.8

* The savings represent the average LCC for affected consumers. Numbers in parentheses denote negative values.

Table V.6 Average LCC and PBP Results for Small Electric Storage Water Heaters (20 gal ≤ V_{eff} ≤ 35 gal and FHR < 51 gal)

TSL	Efficiency Level	Average Costs *2022$*				Simple Payback *years*	Average Lifetime *years*
		Installed Cost	First Year's Operating Cost	Lifetime Operating Cost	LCC		
1,2	0	780	314	3,623	4,403	NA	15.1
3,4,5,6	1	3,015	178	2,138	5,153	16.5	15.1

Note: The results for each TSL are calculated assuming that all consumers use products at that efficiency level. The PBP is measured relative to the baseline product.

Table V.7 Average LCC Savings Relative to the No-New-Standards Case for Small Electric Storage Water Heaters (20 gal ≤ V_{eff} ≤ 35 gal and FHR < 51 gal)

TSL	Efficiency Level	Life-Cycle Cost Savings	
		Average LCC Savings* *2022$*	Percent of Consumers that Experience Net Cost
1,2	0	NA	0.0
3,4,5,6	1	(750)	76.5

* The savings represent the average LCC for affected consumers. Numbers in parentheses denote negative values.

Table V.8 Average LCC and PBP Results for Electric Storage Water Heaters (20 gal ≤ V_{eff} ≤ 55 gal, excluding Small Electric Storage Water Heaters)

TSL	Efficiency Level	Average Costs 2022$				Simple Payback years	Average Lifetime years
		Installed Cost	First Year's Operating Cost	Lifetime Operating Cost	LCC		
1	0	902	340	3,891	4,793	NA	15.1
2,3	1	1,855	171	2,047	3,902	5.6	15.1
4	2	1,903	139	1,700	3,602	5.0	15.1
5,6	3	1,995	130	1,600	3,594	5.2	15.1

Note: The results for each TSL are calculated assuming that all consumers use products at that efficiency level. The PBP is measured relative to the baseline product.

Table V.9 Average LCC Savings Relative to the No-New-Standards Case for Electric Storage Water Heaters (20 gal ≤ V_{eff} ≤ 55 gal, excluding Small Electric Storage Water Heaters)

TSL	Efficiency Level	Life-Cycle Cost Savings	
		Average LCC Savings* 2022$	Percent of Consumers that Experience Net Cost
1,2	0	NA	0.0
2,3	1	859	34.7
4	2	1,146	32.7
5,6	3	1,067	38.2

* The savings represent the average LCC for affected consumers. Numbers in parentheses denote negative values.

Table V.10 Average LCC and PBP Results for Electric Storage Water Heaters (55 gal < V_{eff} ≤ 120 gal)

TSL	Efficiency Level	Average Costs 2022$				Simple Payback years	Average Lifetime years
		Installed Cost	First Year's Operating Cost	Lifetime Operating Cost	LCC		
0	0	2,019	290	3,368	5,387	NA	15.1
1,2,3	1	2,028	244	2,857	4,885	0.2	15.1
4	2	2,064	194	2,303	4,367	0.5	15.1
5,6	3	2,180	176	2,101	4,282	1.4	15.1

Note: The results for each TSL are calculated assuming that all consumers use products at that efficiency level. The PBP is measured relative to the baseline product.

Table V.11 Average LCC Savings Relative to the No-New-Standards Case for Electric Storage Water Heaters (55 gal < V_{eff} ≤ 120 gal)

TSL	Efficiency Level	Life-Cycle Cost Savings	
		Average LCC Savings* 2022$	Percent of Consumers that Experience Net Cost
1,2,3	1	458	0.3
4	2	613	1.4
5,6	3	190	38.8

* The savings represent the average LCC for affected consumers. Numbers in parentheses denote negative values.

b. Consumer Subgroup Analysis

In the consumer subgroup analysis, DOE estimated the impact of the considered TSLs on low-income households, senior-only households, and small businesses. Table V.12 through Table V.16 compare the average LCC savings and PBP at each efficiency level for the consumer subgroups with similar metrics for the entire consumer sample for each consumer water heater product class analyzed. In most cases, the average LCC savings and PBP for low-income households and senior-only households at the considered efficiency levels are not substantially different from the average for all households. Chapter 11 of the final rule TSD presents the complete LCC and PBP results for the subgroups.

Table V.12 Comparison of LCC Savings and PBP for Consumer Subgroups and All Households; Gas-fired Storage Water Heaters (20 gal ≤ V_{eff} ≤ 55 gal)

TSL	Low-Income Households	Senior-Only Households	Small Businesses	All Households
Average LCC Savings (2022$)				
1	31	25	(11)	15
2,3,4,5	81	47	(39)	29
6	71	(282)	(372)	(285)
Simple Payback Period (years)				
1	4.0	7.2	9.6	8.4
2,3,4,5	4.6	8.1	9.9	9.1
6	9.3	20.1	15.3	18.5
Consumers with Net Cost (%)				
1	11.4	15.1	37.4	20.3
2,3,4,5	26.1	37.8	61.3	40.5
6	37.7	66.0	76.2	69.8
Consumers with Net Benefit (%)				
1	41.4	39.9	21.2	36.4
2,3,4,5	50.7	40.7	17.9	38.2
6	57.3	31.3	23.8	29.3

Table V.13 Comparison of LCC Savings and PBP for Consumer Subgroups and All Households; Oil-fired Storage Water Heaters (V_{eff} ≤ 50 gal)

TSL	Low-Income Households	Senior-Only Households	Small Businesses	All Households
Average LCC Savings (2022$)				
1	159	134	33	123
2,3,4,5,6	236	158	(10)	141
Simple Payback Period (years)				
1	2.5	4.5	5.3	4.7
2,3,4,5,6	3.4	6.3	7.4	6.5
Consumers with Net Cost (%)				
1	5.3	7.7	19.5	10.8
2,3,4,5,6	8.9	23.9	48.3	26.8
Consumers with Net Benefit (%)				
1	58.3	57.0	47.4	55.7
2,3,4,5,6	74.3	59.6	36.2	56.7

Table V.14 Comparison of LCC Savings and PBP for Consumer Subgroups and All Households; Small Electric Storage Water Heaters (20 gal ≤ V_{eff} ≤ 35 gal and FHR < 51 gal)

TSL	Low-Income Households	Senior-Only Households	Small Businesses	All Households
Average LCC Savings (2022$)				
1,2*	NA	NA	NA	NA
3,4,5,6	788	(321)	(1662)	(750)
Simple Payback Period (years)				
1,2*	NA	NA	NA	NA
3,4,5,6	6.0	15.1	28.0	16.5
Consumers with Net Cost (%)				
1,2*	NA	NA	NA	NA
3,4,5,6	29.5	57.0	88.8	76.5
Consumers with Net Benefit (%)				
1,2*	NA	NA	NA	NA
3,4,5,6	65.0	39.2	9.9	22.5

* TSLs 1 and 2 represent no new amended standards for small electric storage water heaters.

Table V.15 Comparison of LCC Savings and PBP for Consumer Subgroups and All Households; Electric Storage Water Heaters (20 gal ≤ V_{eff} ≤ 55 gal, Except Small Electric Storage Water Heaters)

TSL	Low-Income Households	Senior-Only Households	Small Businesses	All Households
Average LCC Savings (2022$)				
1*	NA	NA	NA	NA
2,3	1579	433	295	859
4	1934	610	453	1146
5,6	1858	555	374	1067
Simple Payback Period (years)				
1*	NA	NA	NA	NA
2,3	2.8	6.9	4.8	5.6
4	2.5	6.1	4.3	5.0
5,6	2.5	6.4	4.6	5.2
Consumers with Net Cost (%)				
1*	NA	NA	NA	NA
2,3	16.2	32.7	63.9	34.7
4	14.6	31.0	63.7	32.7
5,6	16.2	36.1	70.1	38.2
Consumers with Net Benefit (%)				
1*	NA	NA	NA	NA
2,3	69.2	53.0	24.1	53.4
4	71.6	55.6	24.9	56.4
5,6	77.0	57.5	26.7	58.1

* TSL 1 represents no new amended standards for electric storage water heaters (20 gal ≤ V_{eff} ≤ 55 gal, except small electric storage water heaters).

Table V.16 Comparison of LCC Savings and PBP for Consumer Subgroups and All Households; Electric Storage Water Heaters (55 gal < V_{eff} ≤ 120 gal)

TSL	Low-Income Households	Senior-Only Households	Small Businesses	All Households
Average LCC Savings (2022$)				
1,2,3	464	372	398	458
4	674	432	419	613
5,6	279	97	84	190
Simple Payback Period (years)				
1,2,3	0.1	0.3	0.2	0.2
4	0.2	0.7	0.4	0.5
5,6	0.7	2.1	1.3	1.4
Consumers with Net Cost (%)				
1,2,3	0.1	0.2	0.7	0.3
4	0.4	1.0	4.8	1.4
5,6	16.5	36.0	66.2	38.8
Consumers with Net Benefit (%)				
1,2,3	4.4	3.9	2.8	3.4
4	14.8	13.6	9.1	13.9
5,6	69.7	47.1	24.0	50.5

c. Rebuttable Presumption Payback

As discussed in section III.F.2 of this document, EPCA establishes a rebuttable presumption that an energy conservation standard is economically justified if the increased purchase cost for a product that meets the standard is less than three times the value of the first-year energy savings resulting from the standard. In calculating a rebuttable presumption payback period for each of the considered TSLs, DOE used discrete values, and, as required by EPCA, based the energy use calculation on the DOE test procedures for consumer water heaters. In contrast, the PBPs presented in section V.B.1.a of this document were calculated using distributions that reflect the range of energy use in the field.

Table V.17 presents the rebuttable-presumption payback periods for the considered TSLs for consumer water heaters. While DOE examined the rebuttable-presumption criterion, it considered whether the standard levels considered for this rule are economically justified through a more detailed analysis of the economic impacts of those levels, pursuant to 42 U.S.C. 6295(o)(2)(B)(i), that considers the full range of impacts to the consumer, manufacturer, Nation, and environment. The results of that analysis serve as the basis for DOE to definitively evaluate the economic justification for a potential standard level, thereby supporting or rebutting the results of any preliminary determination of economic justification.

Table V.17 Comparison of Rebuttable-Presumption Payback Periods

TSL	1	2	3	4	5	6
GSWH	5.8	7.4	7.4	7.4	7.4	12.4
OSWH	4.1	5.7	5.7	5.7	5.7	5.7
ESWH (20 gal ≤ V_{eff} ≤ 35 gal, FHR < 51 gal)	NA	NA	12.4	12.4	12.4	12.4
ESWH (20 gal ≤ V_{eff} ≤ 55 gal, excluding Small ESWH)	NA	3.7	3.7	3.2	3.4	3.4
ESWH (55 gal < V_{eff} ≤ 120 gal)	0.3	0.3	0.3	0.6	1.5	1.5

2. Economic Impacts on Manufacturers

DOE performed an MIA to estimate the impact of amended energy conservation standards on manufacturers of consumer water heaters. The next section describes the expected impacts on manufacturers at each considered TSL. Chapter 12 of the final rule TSD explains the analysis in further detail.

a. Industry Cash Flow Analysis Results

In this section, DOE provides GRIM results from the analysis, which examines changes in the industry that would result from a standard. The following tables summarize the estimated financial impacts (represented by changes in INPV) of potential amended energy conservation standards on manufacturers of consumer water heaters, as well as the conversion costs that DOE estimates manufacturers of consumer water heaters would incur at each TSL.

As discussed in section IV.J.2.d of this document, DOE modeled two scenarios to evaluate a range of cash flow impacts on the consumer water heater industry: (1) the preservation of gross margin percentage scenario and (2) the preservation of operating profit. Under the preservation of gross margin percentage scenario, DOE applied a single uniform "gross margin percentage" across all efficiency levels. As MPCs increase with efficiency, this scenario implies that the per-unit dollar profit would also increase. DOE assumed a "gross margin percentage" of 31 percent for gas-fired storage water heaters, 30 percent for oil-fired storage water heaters, and 28 percent for all electric storage water heaters. These gross margin percentages (and corresponding manufacturer markups) are the same as the ones DOE assumed in the engineering analysis and the no-new-standards case of the GRIM. Because this scenario assumes that a manufacturer's absolute dollar markup would increase as MPCs increase in the standards cases, it represents the upper bound to industry profitability under potential new energy conservation standards.

The preservation of operating profit scenario reflects manufacturers' concerns about their inability to maintain margins as MPCs increase to reach more stringent efficiency levels. In this scenario, while manufacturers make the necessary investments required to convert their facilities to produce compliant products, operating profit does not change in absolute dollars and decreases as a percentage of revenue.

Each of the modeled manufacturer markup scenarios results in a unique set of cash flows and corresponding industry values at each TSL. In the following discussion, the INPV results refer to the difference in industry value between the no-new-standards case and each standards case resulting from the sum of discounted cash flows from 2023 through 2059. To provide perspective on the short-run cash flow impact, DOE includes in the discussion of results a comparison of free cash flow between the no-new-standards case and the standards case at each TSL in the year before new standards are required.

Table V.18 Manufacturer Impact Analysis for Consumer Water Heaters under the Preservation of Gross Margin Scenario

	Units	No-New-Standards Case	Trial Standard Level					
			1	2	3	4	5	6
INPV	*2022$ millions*	1,478.8	1,484.2	1,506.9	1,438.9	1,447.6	1,447.5	1,473.5
Change in INPV*	*2022$ millions*	-	5.5	28.2	(39.8)	(31.2)	(31.3)	(5.2)
	%	-	0.4	1.9	(2,7)	(2.1)	(2.1)	(0.4)
Free Cash Flow (2029)	*2022$ millions*	124.0	121.0	17.3	(24.1)	(29.3)	(48.8)	(155.0)
Change in Free Cash Flow (2029)	*2022$ millions*	-	(3.0)	(106.7)	(148.1)	(153.3)	(172.8)	(279.0)
	%	-	(2.4)	(86.0)	(119.4)	(123.6)	(139.4)	(225.0)
Product Conversion Costs	*2022$ millions*	-	3.5	11.1	13.3	13.6	14.6	25.1
Capital Conversion Costs	*2022$ millions*	-	4.0	228.7	319.0	330.4	373.1	601.1
Total Investment Required**	*2022$ millions*	-	7.5	239.8	332.4	344.0	387.6	626.2

* Numbers in parentheses indicate a negative number.
**Numbers may not sum exactly due to rounding.

Table V.19 Manufacturer Impact Analysis for Consumer Water Heaters under the Preservation of Operating Profit Scenario

	Units	No-New-Standards Case	Trial Standard Level*					
			1	2	3	4	5	6
INPV	*2022$ millions*	1,478.8	1,470.3	1,203.4	1,087.2	1,058.6	1,000.7	769.2
Change in INPV	*2022$ millions*	-	(8.4)	(275.3)	(391.5)	(420.1)	(478.1)	(709.5)
	%	-	(0.6)	(18.6)	(26.5)	(28.4)	(32.3)	(48.0)
Free Cash Flow (2029)	*2022$ millions*	124.0	121.0	17.3	(24.1)	(29.3)	(48.8)	(155.0)
Change in Free Cash Flow (2029)	*2022$ millions*	-	(3.0)	(106.7)	(148.1)	(153.3)	(172.8)	(279.0)
	%	-	(2.4)	(86.0)	(119.4)	(123.6)	(139.4)	(225.0)
Product Conversion Costs	*2022$ millions*	-	3.5	11.1	13.3	13.6	14.6	25.1
Capital Conversion Costs	*2022$ millions*	-	4.0	228.7	319.0	330.4	373.1	601.1
Total Investment Required**	*2022$ millions*	-	7.5	239.8	332.4	344.0	387.6	626.2

* Numbers in parentheses indicate a negative number.
**Numbers may not sum exactly due to rounding.

At TSL 1, DOE estimates that impacts on INPV would range from -$8.4 million to $5.5 million, or a change in INPV of -0.6 percent to 0.4 percent. At TSL 1, industry free cash flow is $121.0 million, which is a decrease of $3.0 million, or a drop of 2.4 percent, compared to the no-new-standards case value of $124.0 million in 2029, the year leading up to the standards year. Industry conversion costs total $7.5 million. At TSL 1, approximately 73 percent of consumer water heater shipments are expected to meet the required efficiency levels by the analyzed 2030 compliance date.

TSL 1 would set the energy conservation standard for gas-fired storage water heaters at EL 1, oil-fired storage water heaters at EL 1, small electric storage water heaters at baseline efficiency level (*i.e.*, EL 0), electric storage water heaters with an effective storage volume of at least 20 gallons and less than or equal to 55 gallons (excluding small electric storage water heaters) at baseline, and electric storage water heaters with effective storage volumes above 55 gallons at EL 1. At TSL 1, DOE estimates that manufacturers would incur approximately $3.5 million in product conversion costs, as some gas-fired storage water heaters and electric storage water heaters would need to be redesigned to comply with the standard. DOE also estimates that manufacturers would incur approximately $4.0 million in capital conversion costs at TSL 1 to accommodate the need for increased capacity for gas-fired and electric storage water heaters.

At TSL 1, the shipment-weighted average MPC for consumer water heaters covered by this rulemaking increases by 1.6 percent relative to the no-new-standards case shipment-weighted average MPC for all water heaters in 2030. Given the relatively small increase in production costs, DOE does not project a notable drop in shipments in the year the standard takes effect. In the preservation of gross margin scenario, manufacturers are able to fully pass on this slight cost increase to consumers. In the preservation of gross margin percentage scenario, the slight increase in cashflow from the higher MSP outweighs the $7.5 million in conversion costs, causing a slightly positive change in INPV at TSL 1 under this scenario.

Under the preservation of operating profit scenario, manufacturers earn the same per-unit operating profit as would be earned in the no-new-standards case in 2031 (a year after the analyzed compliance year), but manufacturers do not earn additional profit from their investments. In this scenario, the manufacturer markup decreases in 2031. This reduction in the manufacturer markup and the $7.5 million in conversion costs incurred by manufacturers cause a slightly negative change in INPV at TSL 1 under the preservation of operating profit scenario.

At TSL 2, DOE estimates that impacts on INPV would range from -$275.3 million to $28.2 million, or a change in INPV of -18.6 percent to 1.9 percent. At TSL 2, industry free cash flow is $17.3 million, which is a decrease of $106.7 million, or a drop of 86.0 percent compared to the no-new-standards case value of $124.0 million in 2029, the year leading up to the standards year. Industry conversion costs total $239.8 million. At TSL 2, approximately 24 percent of consumer water heater shipments are expected to meet the required efficiency levels by the analyzed 2030 compliance date.

TSL 2 would set the energy conservation standard for gas-fired storage water heaters at EL 2, oil-fired storage water heaters at EL 2, small electric storage water heaters at baseline, electric storage water heaters with an effective storage volume of at least 20 gallons and less than 55 gallons (excluding small electric storage water heaters) at EL 1, and electric storage water heaters with an effective storage volume of above 55 gallons at EL 1. At TSL 2, DOE estimates that manufacturers would incur approximately $11.1 million in product conversion costs, as some gas-fired storage water heaters and electric storage water heaters would need to be redesigned to comply with the standard. While small electric storage water heaters could remain reliant on electric resistance technology, most electric storage water heaters would need to transition to heat pump technology. In 2023, heat pump electric storage water heaters comprise approximately 3 percent of the electric storage water heater market. At TSL 2, heat pump water heaters are expected to comprise approximately 61 percent of the electric storage water heater market in 2030 since all electric storage water heaters (except for small electric storage) would need to meet heat pump levels, driving large investments to expand production capacity of heat exchangers and to optimize production costs. Driven by the need for increased heat exchanger production capacity, DOE estimates that manufacturers would incur approximately $207.6 million in capital conversion costs for electric storage water heaters (and $228.7 million in capital conversion costs for all product classes) at TSL 2.

At TSL 2, the shipment-weighted average MPC for consumer water heaters covered by this rulemaking increases by 36.6 percent relative to the no-new-standards case shipment-weighted average MPC for all water heaters in 2030. Despite an increase in production costs, DOE does not project a notable drop in shipments in the year the standard takes effect. In the preservation of gross margin scenario, manufacturers are able to fully pass on this cost increase to consumers. In the preservation of gross margin percentage scenario, the increase in cashflow from the higher MSP outweighs the $239.8 in conversion costs, causing a slightly positive change in INPV at TSL 2 under this scenario.

Under the preservation of operating profit scenario, manufacturers earn the same per-unit operating profit as would be earned in the no-new-standards case in 2031 (a year after the analyzed compliance year), but manufacturers do not earn additional profit from their investments. In this scenario, the manufacturer markup decreases in 2031. This reduction in the manufacturer markup and the $239.8 million in conversion costs incurred by manufacturers cause a negative change in INPV at TSL 2 under the preservation of operating profit scenario.

At TSL 3, DOE estimates that impacts on INPV would range from -$391.5 million to -$39.8 million, or a change in INPV of -26.5 percent to -2.7 percent. At TSL 3, industry free cash flow is -$24.1 million, which is a decrease of $148.1 million, or a drop of 119.4 percent, compared to the no-new-standards case value of $124.0 million in 2029, the year leading up to the standards year. Industry conversion costs total $332.4 million. At TSL 3, approximately 17 percent of consumer water heater shipments are expected to meet the required efficiency levels by the analyzed 2030 compliance date.

TSL 3 would set the energy conservation standard for gas-fired storage water heaters at EL 2, oil-fired storage water heaters at EL 2, small electric storage water heaters at EL 1, electric storage water heaters with an effective storage volume of at least 20 gallons and less than 55 gallons (excluding small electric storage water heaters) at EL 1, and electric storage water heaters with an effective storage volume of above 55 gallons at EL 1. At TSL 3, DOE estimates that manufacturers would incur approximately $13.3 million in product conversion costs, as some gas-fired storage water heaters and electric storage water heaters with an effective storage volume of between 20 and 55 gallons would need to be redesigned to comply with the standard. In 2023, heat pump electric storage water heaters comprise approximately 3 percent of the electric storage water heater market. In 2030 (the analyzed compliance year), heat pump electric storage water heaters would comprise 100 percent of the electric storage water heater market, driving large investments in product redesign and expanding heat exchanger manufacturing capacity. This would necessitate small electric storage water heater manufacturers developing split-system heat pump designs. Driven by the need for increased heat exchanger production capacity, DOE estimates that the industry would incur approximately $297.9 million in capital conversion costs for electric storage water heaters (and $319.0 million in capital conversion costs for all product classes) at TSL 3.

At TSL 3, the large conversion costs result in a free cash flow dropping below zero in the years before the standards year. The negative free cash flow calculation indicates manufacturers may need to access cash reserves or outside capital to finance conversion efforts.

At TSL 3, the shipment-weighted average MPC for consumer water heaters covered by this rulemaking increases by 54.7 percent relative to the no-new-standards case shipment-weighted average MPC for all water heaters in 2030. Given the projected increase in production costs, DOE expects an estimated 15.4 percent drop in shipments in the year the standard takes effect relative to the no-new-standards case. The increase in cashflow from the higher MSP is outweighed by the $332.4 million in conversion costs and the drop in annual shipments, causing a slightly negative change in INPV at TSL 3 under this scenario.

Under the preservation of operating profit scenario, manufacturers earn the same per-unit operating profit as would be earned in the no-new-standards case in 2031 (a year after the analyzed compliance year), but manufacturers do not earn additional profit from their investments. In this scenario, the manufacturer markup decreases in 2031. This reduction in the manufacturer markup, $332.4 million in conversion costs incurred by manufacturers, and the drop in annual shipments cause a large negative change in INPV at TSL 3 under the preservation of operating profit scenario.

At TSL 4, DOE estimates that impacts on INPV would range from -$420.1 million to -$31.2 million, or a change in INPV of -28.4 percent to -2.1 percent. At TSL 4, industry free cash flow is -$29.3 million, which is a decrease of -$153.3 million, or a drop of 123.6 percent, compared to the no-new-standards case value of $124.0 million in 2029, the year leading up to the standards year. Industry conversion costs total $344.0 million. At TSL 4, approximately 17 percent of consumer water heater shipments are expected to meet the required efficiency levels by the analyzed 2030 compliance date.

TSL 4 would set the energy conservation standard for gas-fired storage water heaters at EL 2, oil-fired storage water heaters at EL 2, small electric storage water heaters at EL 1, electric storage water heaters with an effective storage volume of at least 20 gallons and less than 55 gallons (excluding small electric storage water heaters) at EL 2, and electric storage water heaters with an effective storage volume of above 55 gallons at EL 2. At TSL 4, DOE estimates that manufacturers would incur approximately $13.6 million in product conversion costs, as some gas-fired storage water heaters, electric storage water heaters with an effective storage volume of between 20 and 55 gallons, and electric storage water heaters with an effective storage volume of above 55 gallons would need to be redesigned to comply with the standard. In 2023, heat pump electric storage water heaters comprise approximately 3 percent of the electric storage water heater market. In 2030 (the analyzed compliance year), heat pump electric storage water heaters would comprise 100 percent of the electric storage water heater market, driving large investments in product redesign and expanding heat exchanger manufacturing capacity. This would necessitate small electric storage water heater manufacturers developing split-system heat pump designs. Driven by the need for increased heat exchanger production capacity, DOE estimates that the industry would incur approximately $309.3 million in capital conversion costs for electric storage water heaters (and $330.4 million in capital conversion costs for all product classes) at TSL 4.

At TSL 4, the large conversion costs result in a free cash flow dropping below zero in the years before the standards year. The negative free cash flow calculation indicates manufacturers may need to access cash reserves or outside capital to finance conversion efforts.

At TSL 4, the shipment-weighted average MPC for consumer water heaters covered by this rulemaking increases by 58.7 percent relative to the no-new-standards case shipment-weighted average MPC for all water heaters in 2030. Given the projected increase in production costs, DOE expects an estimated 15.2 percent drop in shipments in the year the standard takes effect relative to the no-new-standards case. The increase in cashflow from the higher MSP is outweighed by the $344.0 million in conversion costs and the drop in annual shipments, causing a slightly negative change in INPV at TSL 4 under this scenario.

Under the preservation of operating profit scenario, manufacturers earn the same per-unit operating profit as would be earned in the no-new-standards case in 2031 (a year after the analyzed compliance year), but manufacturers do not earn additional profit from their investments. In this scenario, the manufacturer markup decreases in 2031. This reduction in the manufacturer markup, $344.0 million in conversion costs incurred by manufacturers, and the drop in annual shipments cause a large negative change in INPV at TSL 4 under the preservation of operating profit scenario.

At TSL 5, DOE estimates that impacts on INPV would range from -$478.1 million to -$31.3 million, or a change in INPV of -32.3 percent to -2.1 percent. At TSL 5, industry free cash flow is -$48.8 million, which is a decrease of $172.8 million, or a drop of 139.4 percent compared to the no-new-standards case value of $124.0 million in 2029, the year leading up to the standards year. Industry conversion costs total $387.6 million. At TSL 5, approximately 14 percent of consumer water heater shipments are expected to meet the required efficiency levels by the analyzed 2030 compliance date.

TSL 5 would set the energy conservation standard for gas-fired storage water heaters at EL 2, oil-fired storage water heaters at EL 2, small electric storage water heaters at EL 1, electric storage water heaters with an effective storage volume of less than 55 gallons (excluding small electric storage water heaters) at EL 3, and electric storage water heaters with effective an volume of above 55 gallons at EL 3. At TSL 5, DOE estimates that manufacturers would incur approximately $14.6 million in product conversion costs, as some gas-fired storage water heaters, electric storage water heaters with an effective storage volume of between 20 and 55 gallons, and electric storage water heaters with an effective storage volume above 55 gallons would need to be redesigned to comply with the standard. In 2023, heat pump electric storage water heaters comprise approximately 3 percent of the electric storage water heater market. At TSL 5, 100 percent of electric storage water heaters would need to meet heat pump levels, driving large investments in product redesign and expanding heat exchanger manufacturing capacity. This would necessitate small electric storage water heater manufacturers developing split-system heat pump designs. Additionally, requiring larger condensers for gas-fired storage water heaters would require significant investments in capacity. Driven by the need for increased heat exchanger production capacity for electric storage water heaters and increased production capacity for larger condensers for gas-fired storage water heaters, DOE estimates that the industry would incur approximately $373.1 million in capital conversion costs at TSL 5.

At TSL 5, the large conversion costs result in a free cash flow dropping below zero in the years before the standards year. The negative free cash flow calculation indicates manufacturers may need to access cash reserves or outside capital to finance conversion efforts.

At TSL 5, the shipment-weighted average MPC for consumer water heaters covered by this rulemaking increases by 66.6 percent relative to the no-new-standards case shipment-weighted average MPC for all water heaters in 2030. Given the projected increase in production costs, DOE expects an estimated 16.0 percent drop in shipments in the year the standard takes effect relative to the no-new-standards case. The increase in cashflow from the higher MSP is outweighed by the $387.6 million in conversion costs and the drop in annual shipments, causing a slightly negative change in INPV at TSL 5 under this scenario.

Under the preservation of operating profit scenario, manufacturers earn the same per-unit operating profit as would be earned in the no-new-standards case in 2031 (a year after the analyzed compliance year), but manufacturers do not earn additional profit from their investments. In this scenario, the manufacturer markup decreases in 2031. This reduction in the manufacturer markup, the $387.6 million in conversion costs incurred by manufacturers, and the drop in annual shipments cause a large negative change in INPV at TSL 5 under the preservation of operating profit scenario.

At TSL 6, DOE estimates that impacts on INPV would range from -$709.5 million to -$5.2 million, or a change in INPV of -48.0 percent to -0.4 percent. At TSL 6, industry free cash flow is -$155.0 million, which is a decrease of $279.0 million, or a drop of 225.0 percent, compared to the no-new-standards case value of $124.0 million in 2029, the year leading up to the standards year. Industry conversion costs total $626.2 million. At TSL 6, approximately 2 percent of consumer water heater shipments are expected to meet the required efficiency levels by the analyzed 2030 compliance date.

TSL 6 would set the energy conservation standard for gas-fired storage water heaters at EL 5, oil-fired storage water heaters at EL 2, small electric storage water heaters at EL 1, electric storage water heaters with an effective storage volume of less than 55 gallons (excluding small electric storage water heaters) at EL 3, and electric storage water heaters with an effective storage volume of above 55 gallons at EL 3. At TSL 6, DOE estimates that manufacturers would incur approximately $25.1 million in product conversion costs, as some gas-fired storage water heaters and electric storage water heaters with an effective storage volume of between 20 and 55 gallons would need to be redesigned to comply with the standard. In 2023, heat pump electric storage water heaters comprise approximately 3 percent of the electric storage water heater market. At TSL 6, 100 percent of electric storage water heaters would need to meet heat pump levels, driving large investments in product redesign and expanding heat exchanger manufacturing capacity. This would necessitate small electric storage water heater manufacturers developing split-system heat pump designs. Additionally, requiring larger condensers, electronic ignition, power venting, and larger heat exchangers for gas-fired storage water heaters would require significant investments in capacity. Driven by the need for increased heat exchanger production capacity for electric storage water heaters and increased production capacity for electronic ignition, power venting, larger heat exchangers, and larger condensers for gas-fired storage water heaters, DOE estimates that the industry would incur approximately $601.1 million in capital conversion costs at TSL 6.

At TSL 6, the large conversion costs result in a free cash flow dropping below zero in the years before the standards year. The negative free cash flow calculation indicates manufacturers may need to access cash reserves or outside capital to finance conversion efforts.

At TSL 6, the shipment-weighted average MPC for consumer water heaters covered by this rulemaking increases by 101.6 percent relative to the no-new-standards case shipment-weighted average MPC for all water heaters in 2030. Given the projected increase in production costs, DOE expects an estimated 19.4 percent drop in shipments in the year the standard takes effect relative to the no-new-standards case. In this scenario, the increase in cashflow from the higher MSP is outweighed by the $626.2 million in conversion costs and the drop in annual shipments, causing a slightly negative change in INPV at TSL 6 under this scenario.

Under the preservation of operating profit scenario, manufacturers earn the same per-unit operating profit as would be earned in the no-new-standards case in 2031 (a year after the analyzed compliance year), but manufacturers do not earn additional profit from their investments. In this scenario, the manufacturer markup decreases in 2031. This reduction in the manufacturer markup, the $626.2 million in conversion costs, and the drop in annual shipments incurred by manufacturers cause a significant negative change in INPV at TSL 6 under the preservation of operating profit scenario.

b. Direct Impacts on Employment

To quantitatively assess the potential impacts of amended energy conservation standards on direct employment in the consumer water heater industry, DOE used the GRIM to estimate the domestic labor expenditures and number of direct employees in the no-new-standards case and in each of the standards cases during the analysis period.

Labor expenditures related to product manufacturing depend on the labor intensity of the product, the sales volume, and an assumption that wages remain fixed in real terms over time. The total labor expenditures in each year are calculated by multiplying the total MPCs by the labor percentage of MPCs. The total labor expenditures in the GRIM were then converted to total production employment levels by dividing production labor expenditures by the average fully burdened wage multiplied by the average number of hours worked per year per production worker. To do this, DOE relied on hourly wages from the engineering analysis and the *ASM* inputs[179]: Production Workers' Annual Hours, Production Workers for Pay Period, and Number of Employees. DOE also relied on the BLS employee compensation data[180] to determine the fully burdened wage ratio. The

[179] U.S. Census Bureau's Annual Survey of Manufactures: 2018-2021 (Available at: www.census.gov/programs-surveys/asm/data/tables.html) (last accessed January 18, 2024).
[180] U.S. Bureau of Labor Statistics. *Employer Costs for Employee Compensation*. (September 2023) (Dec. 15, 2023) Available at *www.bls.gov/news.release/archives/ecec_12152023.pdf* (last accessed Jan. 1, 2024).

fully burdened wage ratio factors in paid leave, supplemental pay, insurance, retirement and savings, and legally required benefits.

The number of production employees is then multiplied by the U.S. labor percentage to convert total production employment to total domestic production employment. The U.S. labor percentage represents the industry fraction of domestic manufacturing production capacity for the covered product. This value is derived from manufacturer interviews, product database analysis, and publicly available information. DOE estimates that 80 percent of consumer water heaters analyzed in this final rule are produced domestically.

The domestic production employees estimate covers production line workers, including line supervisors, who are directly involved in fabricating and assembling products within the OEM facility. Workers performing services that are closely associated with production operations, such as materials handling tasks using forklifts, are also included as production labor. DOE's estimates only account for production workers who manufacture the specific products covered by this final rule.

Non-production employees account for the remainder of the direct employment figure. The non-production employees estimate covers domestic workers who are not directly involved in the production process, such as sales, engineering, human resources, and management. Using the amount of domestic production workers calculated above, non-production domestic employees are extrapolated by multiplying the ratio of non-production workers in the industry compared to production employees. DOE assumes that this employee distribution ratio remains constant between the no-new-standards case and standards cases.

Direct employment is the sum of domestic production employees and non-production employees. Using the GRIM, DOE estimates in the absence of new energy conservation standards there would be 4,110 domestic production and non-production employees for consumer water heaters in 2030. Table V.20 shows the range of the impacts of energy conservation standards on U.S. manufacturing employment in the consumer water heaters industry. The following discussion provides a qualitative evaluation of the range of potential impacts presented in Table V.20 .

Table V.20 Domestic Direct Employment Impacts for Consumer Water Heater Manufacturers in 2030

	No-New-Standards Case	TSL 1	TSL 2	TSL 3	TSL 4	TSL 5	TSL 6
Direct Employment in 2030 (Production workers + Non-Production Workers)	4,110	4,110 to 4,120	2,941 to 5,544	2,393 to 5,480	2,393 to 5,504	2,393 to 5,760	441 to 7,350
Potential Changes in Direct Employment Workers in 2030*	-	0 to 10	(1,168) to 1,434	(1,716) to 1,370	(1,716) to 1,394	(1,716) to 1,650	(3,669) to 3,240

*DOE presents a range of potential employment impacts. Numbers in parentheses denote negative values.

The direct employment impacts shown in Table V.20 represent the potential domestic employment changes that could result following the compliance date for the consumer water heater product classes analyzed in this final rule. Manufacturing employment could increase or decrease due to the labor content of the various products being manufactured domestically or if manufacturers decided to move production facilities abroad because of the amended standards. The upper-bound estimate corresponds to an increase in the number of domestic workers that would result from amended energy conservation standards if manufacturers continue to produce the same scope of covered products within the United States after compliance takes effect. The lower-bound estimate reflects the risk of manufacturers re-evaluating production siting decisions in response to amended energy conservation standards. This conservative lower bound of domestic direct employment varies by TSL and product class. For this final rule, DOE reassessed and adjusted its conservative lower bound of potential domestic direct employment impacts to account for the potential that gas-fired storage water heater OEMs may re-evaluate domestic manufacturing locations at certain analyzed TSLs.

For electric storage water heaters (which account for approximately 51 percent of shipments in 2030), the lower end of the domestic employment range represents the potential decrease in production workers if manufacturing of heat pump electric storage water heaters moves to lower labor-cost countries in response to the large investments necessary to expand heat exchanger production capacity. To establish the estimated change in domestic direct employment for electric storage water heaters, the direct employment analysis assumed a reduction in domestic employment commensurate with the percentage of electric storage water heater shipments that transition to heat pump designs. For gas-fired storage water heaters (which account for approximately 49 percent of shipments in 2030), the lower bound represents a shift of all domestic production workers to foreign production locations at max-tech (TSL 6). At max-tech, it is possible that manufacturers would revisit their siting decisions based on the need for increased production capacity for larger condensers. DOE applied this conservative assumption to establish a lower bound that avoids underestimating the potential direct employment impacts.

Additional detail on the analysis of direct employment can be found in chapter 12 of the final rule TSD. Additionally, the employment impacts discussed in this section are independent of the employment impacts from the broader U.S. economy, which are documented in chapter 16 of the final rule TSD.

c. Impacts on Manufacturing Capacity

Industry concerns around manufacturing capacity were driven by potential technology transitions. In particular, manufacturers focused on the transition to heat pump technology for electric storage water heaters with rated storage volumes of between 20 and 55 gallons. The vast majority of sales today in this product class are electric resistance water heaters. DOE estimates that approximately 3 percent of current electric storage consumer water heater sales are heat pump units. At the final rule level, all electric storage water heaters, excluding small electric storage water heaters, would need to incorporate heat pump technology. Industry would need to add capacity to produce an additional three to four million heat pump electric storage water heater units per year. In interviews, manufacturers noted that heat pump electric storage water heaters are more complex to manufacture than electric resistance water heaters. DOE estimated conversion costs based on both industry feedback and estimates of capital investment from the engineering analysis. DOE's analysis indicated significant investment in additional production floor space and in production capacity for heat exchangers. At TSL 2, conversion costs total $239.8 million, presuming all OEMs of electric storage water heaters, excluding small electric storage water heaters, invest in the transition to heat pump models.

d. Impacts on Subgroups of Manufacturers

As discussed in section IV.J.1 of this document, using average cost assumptions to develop an industry cash flow estimate may not be adequate for assessing differential impacts among manufacturer subgroups. Small manufacturers, niche manufacturers, and manufacturers exhibiting a cost structure substantially different from the industry average could be affected disproportionately. DOE used the results of the industry characterization to group manufacturers exhibiting similar characteristics. Consequently, DOE identified small business manufacturers as a subgroup for a separate impact analysis.

For the small business subgroup analysis, DOE applied the small business size standards published by the U.S. Small Business Administration ("SBA") to determine whether a company is considered a small business. The size standards are codified at 13 CFR part 121. To be categorized as a small business under North American Industry Classification System ("NAICS") code 335220, "Major Household Appliance Manufacturing," a consumer water heater manufacturer and its affiliates may employ a maximum of 1,500 employees. The 1,500-employee threshold includes all employees in a business's parent company and any other subsidiaries. Based on this classification, DOE identified three manufacturers that qualify as domestic small businesses.

The small business subgroup analysis is discussed in more detail in chapter 12 of the final rule TSD. DOE examines the potential impacts of this final rule on small business manufacturers in section VI.B of this document.

e. Cumulative Regulatory Burden

One aspect of assessing manufacturer burden involves looking at the cumulative impact of multiple DOE standards and the regulatory actions of other Federal agencies and States that affect the manufacturers of a covered product or equipment. While any one regulation may not impose a significant burden on manufacturers, the combined effects of several existing or impending regulations may have serious consequences for some manufacturers, groups of manufacturers, or an entire industry. Multiple regulations affecting the same manufacturer can strain profits and lead companies to abandon product lines or markets with lower expected future returns than competing products. For these reasons, DOE conducts an analysis of cumulative regulatory burden as part of its rulemakings pertaining to appliance efficiency.

For the cumulative regulatory burden analysis, DOE examined Federal, product-specific regulations that could affect consumer water heater manufacturers and that take effect approximately 3 years before or after the estimated compliance date (2030). This information is presented in Table V.21.

Table V.21 Compliance Dates and Expected Conversion Expenses of Federal Energy Conservation Standards Affecting Consumer Water Heater Original Equipment Manufacturers

Federal Energy Conservation Standard	Number of OEMs*	Number of OEMs Affected by Today's Rule**	Approx. Standards Compliance Year	Industry Conversion Costs *(millions)*	Industry Conversion Costs / Equipment Revenue***
Miscellaneous Refrigeration Products† 88 FR 19382 (March 31, 2023)	38	2	2029	$126.9 (2021$)	3.1%
Dishwashers† 88 FR 32514 (May 19, 2023)	22	3	2027	$125.6 (2021$)	2.1%
Room Air Conditioners 88 FR 34298 (May 26, 2023)	8	3	2026	$24.8 (2021$)	0.4%
Consumer Pool Heaters 88 FR 34624 (May 30, 2023)	20	3	2028	$48.4 (2021$)	1.5%
Microwave Ovens 88 FR 39912 (June 20, 2023)	18	3	2026	$46.1 (2021$)	0.7%
Consumer Boilers† 88 FR 55128 (August 14, 2023)	24	5	2030	$98.0 (2022$)	3.6%
Walk-in Coolers and Freezers† 88 FR 60746 (September 5, 2023)	79	2	2027	$89.0 (2022$)	0.8%
Commercial Water Heating Equipment 88 FR 69686 (October 6, 2023)	15	5	2026	$42.7 (2022$)	5.3%
Commercial Refrigerators, Refrigerator-Freezers, and Freezers† 88 FR 70196 (October 10, 2023)	83	1	2028	$226.4 (2022$)	1.6%
Dehumidifiers† 88 FR 76510 (November 6, 2023)	20	2	2028	$6.9 (2022$)	0.4%
Consumer Furnaces 88 FR 87502 (December 18, 2023)	15	3	2029	$162.0 (2022$)	1.8%

Refrigerators, Refrigerator-Freezers, and Freezers 89 FR 3026 (January 17, 2024)	63	3	2029 and 2030‡	$830.3 (2022$)	1.3%
Consumer Conventional Cooking Products 89 FR 11434 (February 14, 2024)	35	3	2028	$66.7 (2022$)	0.3%
Consumer Clothes Dryers 89 FR 18164 (March 12, 2024)	19	3	2028	$180.7 (2022$)	1.4%
Residential Clothes Washers 89 FR 19026 (March 15, 2024)	22	3	2028	$320.0 (2022$)	1.8%

* This column presents the total number of OEMs identified in the energy conservation standard rule that is contributing to cumulative regulatory burden.
** This column presents the number of OEMs producing consumer water heaters that are also listed as OEMs in the identified energy conservation standard that is contributing to cumulative regulatory burden.
*** This column presents industry conversion costs as a percentage of product revenue during the conversion period. Industry conversion costs are the upfront investments manufacturers must make to sell compliant products/equipment. The revenue used for this calculation is the revenue from just the covered product/equipment associated with each row. The conversion period is the timeframe over which conversion costs are made and lasts from the publication year of the final rule to the compliance year of the energy conservation standard. The conversion period typically ranges from 3 to 5 years, depending on the rulemaking.
† These rulemakings are at the NOPR stage, and all values are subject to change until finalized through publication of a final rule.
‡ For the refrigerators, refrigerator-freezers, and freezers energy conservation standards direct final rule, the compliance year (2029 or 2030) varies by product class.

DOE received several comments in response to the July 2023 NOPR about cumulative regulatory burden. DOE addresses those comments in section IV.J.3.b of this document.

3. National Impact Analysis

This section presents DOE’s estimates of the national energy savings and the NPV of consumer benefits that would result from each of the TSLs considered as potential amended standards.

a. National Energy Savings

To estimate the energy savings attributable to potential amended standards for consumer water heaters, DOE compared their energy consumption under the no-new-standards case to their anticipated energy consumption under each TSL. The savings are measured over the entire lifetime of products purchased in the 30-year period that begins in the year of anticipated compliance with amended standards (2030–2059). Table V.22 presents DOE's projections of the national energy savings for each TSL considered for consumer water heaters. The savings were calculated using the approach described in section IV.H.2 of this document.

Table V.22 Cumulative National Energy Savings for Consumer Water Heaters; 30 Years of Shipments (2030–2059)

	Trial Standard Level					
	1	**2**	**3**	**4**	**5**	**6**
	quads					
Primary Energy						
GSWH	0.37	1.71	1.71	1.71	1.71	6.93
OSWH	0.000	0.001	0.001	0.001	0.001	0.001
Small ESWH	0.00	0.00	0.75	0.75	0.75	0.75
Medium ESWH	0.00	15.33	17.91	21.12	21.73	21.73
Large ESWH	0.001	0.001	0.001	0.005	0.013	0.013
Total Primary Energy	0.4	17.0	20.4	23.6	24.2	29.4
FFC Energy						
GSWH	0.42	1.91	1.91	1.91	1.91	7.80
OSWH	0.000	0.001	0.001	0.001	0.001	0.001
Small ESWH	0.00	0.00	0.77	0.77	0.77	0.77
Medium ESWH	0.00	15.65	18.29	21.61	22.24	22.24
Large ESWH	0.001	0.001	0.001	0.005	0.014	0.014
Total FFC Energy	0.4	17.6	21.0	24.3	24.9	30.8

OMB Circular A-4[181] requires agencies to present analytical results, including separate schedules of the monetized benefits and costs that show the type and timing of benefits and costs. Circular A-4 also directs agencies to consider the variability of key elements underlying the estimates of benefits and costs. For this rulemaking, DOE undertook a sensitivity analysis using 9 years, rather than 30 years, of product shipments. The choice of a 9-year period is a proxy for the timeline in EPCA for the review of certain energy conservation standards and potential revision of and compliance with such revised standards.[182] The review timeframe established in EPCA is generally not synchronized with the product lifetime, product manufacturing cycles, or other factors specific to consumer water heaters. Thus, such results are presented for informational purposes only and are not indicative of any change in DOE's analytical methodology. The NES sensitivity analysis results based on a 9-year analytical period are presented in Table V.23. The impacts are counted over the lifetime of consumer water heaters purchased during the period 2030–2038.

[181] U.S. Office of Management and Budget. *Circular A-4: Regulatory Analysis*. Available at *www.whitehouse.gov/omb/information-for-agencies/circulars* (last accessed Jan. 18. 2024). DOE used the prior version of Circular A-4 (September 17, 2003) in accordance with the effective date of the November 9, 2023 version.

[182] EPCA requires DOE to review its standards at least once every 6 years, and requires, for certain products, a 3-year period after any new standard is promulgated before compliance is required, except that in no case may any new standards be required within 6 years of the compliance date of the previous standards. (42 U.S.C. 6295(m)) While adding a 6-year review to the 3-year compliance period adds up to 9 years, DOE notes that it may undertake reviews at any time within the 6-year period and that the 3-year compliance date may yield to the 6-year backstop. A 9-year analysis period may not be appropriate given the variability that occurs in the timing of standards reviews and the fact that for some products, the compliance period is 5 years rather than 3 years.

Table V.23 Cumulative National Energy Savings for Consumer Water Heaters; 9 Years of Shipments (2030–2038)

	Trial Standard Level					
	1	2	3	4	5	6
	quads					
Primary Energy						
GSWH	0.12	0.55	0.55	0.55	0.55	2.13
OSWH	0.000	0.000	0.000	0.000	0.000	0.000
Small ESWH	0.00	0.00	0.17	0.17	0.17	0.17
Medium ESWH	0.00	4.57	5.26	6.20	6.35	6.35
Large ESWH	0.000	0.000	0.000	0.001	0.004	0.004
Total Primary Energy	0.1	5.1	6.0	6.9	7.1	8.7
FFC Energy						
GSWH	0.13	0.61	0.61	0.61	0.61	2.39
OSWH	0.000	0.001	0.001	0.001	0.001	0.001
Small ESWH	0.00	0.00	0.18	0.18	0.18	0.18
Medium ESWH	0.00	4.67	5.38	6.34	6.51	6.51
Large ESWH	0.000	0.000	0.000	0.001	0.004	0.004
Total FFC Energy	0.1	5.3	6.2	7.1	7.3	9.1

b. Net Present Value of Consumer Costs and Benefits

DOE estimated the cumulative NPV of the total costs and savings for consumers that would result from the TSLs considered for consumer water heaters. In accordance with OMB's guidelines on regulatory analysis,[183] DOE calculated NPV using both a 7-percent and a 3-percent real discount rate. Table V.24 shows the consumer NPV results with impacts counted over the lifetime of products purchased during the period 2030–2059.

[183] U.S. Office of Management and Budget. *Circular A-4: Regulatory Analysis*. September 17, 2003. *https://www.whitehouse.gov/wp-content/uploads/legacy_drupal_files/omb/circulars/A4/a-4.pdf* (last accessed July 1, 2021).

Table V.24 Cumulative Net Present Value of Consumer Benefits for Consumer Water Heaters; 30 Years of Shipments (2030–2059)

Discount Rate	**Trial Standard Level**					
	1	**2**	**3**	**4**	**5**	**6**
	billion 2022$					
3 percent discount rate						
GSWH	1.53	6.08	6.08	6.08	6.08	9.31
OSWH	0.006	0.011	0.011	0.011	0.011	0.011
Small ESWH	0.00	0.00	(2.81)	(2.81)	(2.81)	(2.81)
Medium ESWH	0.00	75.66	84.69	107.68	108.09	108.09
Large ESWH	0.005	0.005	0.005	0.031	0.068	0.068
Total 3 percent	1.5	82	88	111	111	115
7 percent discount rate						
GSWH	0.43	1.54	1.54	1.54	1.54	(1.74)
OSWH	0.002	0.004	0.004	0.004	0.004	0.004
Small ESWH	0.00	0.00	(2.15)	(2.15)	(2.15)	(2.15)
Medium ESWH	0.00	23.53	25.63	33.99	33.58	33.58
Large ESWH	0.002	0.002	0.002	0.011	0.022	0.022
Total 7 percent	0.4	25	25	33	33	30

The NPV results based on the aforementioned 9-year analytical period are presented in Table V.25. The impacts are counted over the lifetime of products purchased during the period 2030–2038. As mentioned previously, such results are presented for informational purposes only and are not indicative of any change in DOE's analytical methodology or decision criteria.

Table V.25 Cumulative Net Present Value of Consumer Benefits for Consumer Water Heaters; 9 Years of Shipments (2030–2038)

Discount Rate	**Trial Standard Level**					
	1	**2**	**3**	**4**	**5**	**6**
	billion 2022$					
3 percent discount rate						
GSWH	0.58	2.27	2.27	2.27	2.27	0.64
OSWH	0.004	0.007	0.007	0.007	0.007	0.007
Small ESWH	0.00	0.00	(1.51)	(1.51)	(1.51)	(1.51)
Medium ESWH	0.00	27.08	30.09	38.65	38.73	38.73
Large ESWH	0.002	0.002	0.002	0.011	0.024	0.024
Total 3 percent	0.6	29	31	39	40	38
7 percent discount rate						
GSWH	0.21	0.74	0.74	0.74	0.74	(2.31)
OSWH	0.002	0.003	0.003	0.003	0.003	0.003
Small ESWH	0.00	0.00	(1.25)	(1.25)	(1.25)	(1.25)
Medium ESWH	0.00	11.09	12.02	16.18	15.95	15.95
Large ESWH	0.001	0.001	0.001	0.005	0.010	0.010
Total 7 percent	0.2	12	12	16	15	12

The previous results reflect the use of a default trend to estimate the change in price for consumer water heaters over the analysis period (*see* section IV.F.1 of this document). DOE also conducted a sensitivity analysis that considered one scenario with a price decline compared to the reference case and one scenario with a price increase compared to the reference case. The results of these alternative cases are presented in appendix 10C of the final rule TSD. In the price-decline case, the NPV of consumer benefits is higher than in the default case. In the price increase case, the NPV of consumer benefits is lower than in the default case.

c. Indirect Impacts on Employment

DOE estimates that amended energy conservation standards for consumer water heaters will reduce energy expenditures for consumers of those products, with the resulting net savings being redirected to other forms of economic activity. These expected shifts in spending and economic activity could affect the demand for labor. As described in section IV.N of this document, DOE used an input/output model of the U.S. economy to estimate indirect employment impacts of the TSLs that DOE considered. There are uncertainties involved in projecting employment impacts, especially changes in the later years of the analysis. Therefore, DOE generated results for near-term timeframes (2030–2034), where these uncertainties are reduced.

The results suggest that the adopted standards are likely to have a negligible impact on the net demand for labor in the economy. The net change in jobs is so small that it would be imperceptible in national labor statistics and might be offset by other, unanticipated effects on employment. Chapter 16 of the final rule TSD presents detailed results regarding anticipated indirect employment impacts.

4. Impact on Utility or Performance of Products

As discussed in section III.F.1.dof this document, DOE has concluded that the standards adopted in this final rule will not lessen the utility or performance of the consumer water heaters under consideration in this rulemaking. Manufacturers of these products currently offer units that meet or exceed the adopted standards.

5. Impact of Any Lessening of Competition

DOE considered any lessening of competition that would be likely to result from new or amended standards. As discussed in section III.F.1.e of this document, EPCA directs the Attorney General of the United States ("Attorney General") to determine the impact, if any, of any lessening of competition likely to result from a proposed standard and to transmit such determination in writing to the Secretary within 60 days of the publication of a proposed rule, together with an analysis of the nature and extent of the impact. To assist the Attorney General in making this determination, DOE provided the Department of Justice ("DOJ") with copies of the NOPR and the TSD for review. In its assessment letter responding to DOE, DOJ concluded that the proposed energy conservation standards for consumer water heaters are unlikely to have a significant adverse impact on competition. DOE is publishing the Attorney General's assessment at the end of this final rule.

6. Need of the Nation to Conserve Energy

Enhanced energy efficiency, where economically justified, improves the Nation's energy security, strengthens the economy, and reduces the environmental impacts (costs) of energy production. Reduced electricity demand due to energy conservation standards is also likely to reduce the cost of maintaining the reliability of the electricity system, particularly during peak-load periods. Chapter 15 in the final rule TSD presents the estimated impacts on electricity-generating capacity, relative to the no-new-standards case, for the TSLs that DOE considered in this rulemaking.

Energy conservation resulting from potential energy conservation standards for consumer water heaters is expected to yield environmental benefits in the form of reduced emissions of certain air pollutants and greenhouse gases. Table V.26 provides DOE's estimate of cumulative emissions reductions expected to result from the TSLs considered in this rulemaking. The emissions were calculated using the multipliers discussed in section IV.K of this document. DOE reports annual emissions reductions for each TSL in chapter 13 of the final rule TSD.

Table V.26 Cumulative Emissions Reduction for Consumer Water Heaters Shipped in 2030–2059

	Trial Standard Level					
	1	**2**	**3**	**4**	**5**	**6**
Electric Power Sector and Site Emissions						
CO_2 (*million metric tons*)	20	299	342	404	417	716
CH_4 (*thousand tons*)	0.4	20	24	28	29	34
N_2O (*thousand tons*)	0.0	2.8	3.3	3.8	3.9	4.5
SO_2 (*thousand tons*)	0.1	88	107	123	126	124
NO_X (*thousand tons*)	17	153	166	201	209	475
Hg (*tons*)	0.0	0.6	0.7	0.9	0.9	0.9
Upstream Emissions						
CO_2 (*million metric tons*)	2.7	33	37	44	45	87
CH_4 (*thousand tons*)	280	3,038	3,389	4,050	4,199	8,500
N_2O (*thousand tons*)	0.0	0.1	0.2	0.2	0.2	0.3
SO_2 (*thousand tons*)	0.0	1.6	2.0	2.3	2.3	2.5
NO_X (*thousand tons*)	43	512	576	685	710	1,375
Hg (*tons*)	0.000	0.002	0.003	0.003	0.003	0.003
Total FFC Emissions						
CO_2 (*million metric tons*)	22	332	379	448	462	803
CH_4 (*thousand tons*)	280	3,058	3,413	4,078	4,228	8,534
N_2O (*thousand tons*)	0.0	2.9	3.5	4.0	4.1	4.7
SO_2 (*thousand tons*)	0.1	90	109	126	128	127
NO_X (*thousand tons*)	61	665	742	886	919	1,851
Hg (*tons*)	0.0	0.6	0.8	0.9	0.9	0.9

Note: Totals may not equal sums due to rounding.

As part of the analysis for this rule, DOE estimated monetary benefits likely to result from the reduced emissions of CO_2 that DOE estimated for each of the considered TSLs for consumer water heaters. Section IV.L of this document discusses the estimated SC-CO_2 values that DOE used. Table V.27 presents the value of CO_2 emissions reduction at each TSL for each of the SC-CO_2 cases. The time-series of annual values is presented for the selected TSL in chapter 14 of the final rule TSD.

Table V.27 Present Value of CO_2 Emissions Reduction for Consumer Water Heaters Shipped in 2030–2059

TSL	SC-CO_2 Case			
	Discount Rate and Statistics			
	5%	3%	2.5%	3%
	Average	Average	Average	95th percentile
	billion 2022$			
1	0.2	0.9	1.4	2.8
2	3.0	13	21	40
3	3.4	15	24	46
4	4.0	18	28	54
5	4.1	18	29	56
6	7.2	32	51	97

As discussed in section IV.L.2, DOE estimated the climate benefits likely to result from the reduced emissions of methane and N_2O that DOE estimated for each of the considered TSLs for consumer water heaters. Table V.28 presents the value of the CH_4 emissions reduction at each TSL, and Table V.29 presents the value of the N_2O emissions reduction at each TSL. The time-series of annual values is presented for the selected TSL in chapter 14 of the final rule TSD.

Table V.28 Present Value of Methane Emissions Reduction for Consumer Water Heaters Shipped in 2030–2059

TSL	SC-CH_4 Case			
	Discount Rate and Statistics			
	5%	3%	2.5%	3%
	Average	Average	Average	95th percentile
	billion 2022$			
1	0.1	0.4	0.5	1.0
2	1.3	4.0	5.6	11
3	1.4	4.4	6.2	12
4	1.7	5.3	7.4	14
5	1.8	5.5	7.7	14
6	3.6	11	16	30

Table V.29 Present Value of Nitrous Oxide Emissions Reduction for Consumer Water Heaters Shipped in 2030–2059

TSL	SC-N_2O Case			
	Discount Rate and Statistics			
	5%	3%	2.5%	3%
	Average	Average	Average	95th percentile
	billion 2022$			
1	0.00	0.00	0.00	0.00
2	0.01	0.04	0.06	0.11
3	0.01	0.05	0.08	0.13
4	0.01	0.06	0.09	0.15
5	0.01	0.06	0.09	0.16
6	0.02	0.07	0.10	0.18

DOE is well aware that scientific and economic knowledge about the contribution of CO_2 and other GHG emissions to changes in the future global climate and the potential resulting damages to the global and U.S. economy continues to evolve rapidly. DOE, together with other Federal agencies, will continue to review methodologies for estimating the monetary value of reductions in CO_2 and other GHG emissions. This ongoing review will consider the comments on this subject that are part of the public record for this and other rulemakings, as well as other methodological assumptions and issues. DOE notes, however, that the adopted standards are economically justified even without inclusion of monetized benefits of reduced GHG emissions.

DOE also estimated the monetary value of the economic benefits associated with NO_X and SO_2 emissions reductions anticipated to result from the considered TSLs for consumer water heaters. The dollar-per-ton values that DOE used are discussed in section IV.L of this document. Table V.30 presents the present value for NO_X emissions reduction for each TSL calculated using 7-percent and 3-percent discount rates, and Table V.31 presents similar results for SO_2 emissions reductions. The results in these tables reflect application of EPA's low dollar-per-ton values, which DOE used to be conservative. The time-series of annual values is presented for the selected TSL in chapter 14 of the final rule TSD.

Table V.30 Present Value of NO_X Emissions Reduction for Consumer Water Heaters Shipped in 2030–2059

TSL	7% Discount Rate	3% Discount Rate
	million 2022$	
1	710	2,020
2	9,781	27,898
3	11,061	31,658
4	13,023	37,373
5	13,430	38,594
6	23,946	69,019

Table V.31 Present Value of SO_2 Emissions Reduction for Consumer Water Heaters Shipped in 2030–2059

TSL	7% Discount Rate	3% Discount Rate
	million 2022$	
1	2.0	5.6
2	1,926	5,477
3	2,324	6,648
4	2,666	7,626
5	2,723	7,796
6	2,667	7,642

Not all the public health and environmental benefits from the reduction of greenhouse gases, NOx, and SO_2 are captured in the values above, and additional unquantified benefits from the reductions of those pollutants as well as from the reduction of direct PM and other co-pollutants may be significant. DOE has not included monetary benefits of the reduction of Hg emissions because the amount of reduction is very small.

7. Other Factors

The Secretary of Energy, in determining whether a standard is economically justified, may consider any other factors that the Secretary deems to be relevant. (42 U.S.C. 6295(o)(2)(B)(i)(VII)) No other factors were considered in this analysis.

8. Summary of Economic Impacts

Table V.32 presents the NPV values that result from adding the estimates of the economic benefits resulting from reduced GHG and NO_X and SO_2 emissions to the NPV of consumer benefits calculated for each TSL considered in this rulemaking. The consumer benefits are domestic U.S. monetary savings that occur as a result of purchasing the covered products, and are measured for the lifetime of products shipped during the period 2030–2059. The climate benefits associated with reduced GHG emissions resulting from the adopted standards are global benefits, and are also calculated based on the lifetime of consumer water heaters shipped during the period 2030–2059.

Table V.32 Consumer NPV Combined with Present Value of Climate Benefits and Health Benefits

Category	TSL 1	TSL 2	TSL 3	TSL 4	TSL 5	TSL 6
Using 3% Discount Rate for Consumer NPV and Health Benefits (billion 2022$)						
5% Average SC-GHG case	3.9	119	131	162	164	202
3% Average SC-GHG case	4.8	132	146	179	182	235
2.5% Average SC-GHG case	5.5	142	156	192	195	258
3% 95th percentile SC-GHG case	7.3	166	184	224	228	318
Using 7% Discount Rate for Consumer NPV and Health Benefits (billion 2022$)						
5% Average SC-GHG case	1.5	41	43	55	55	67
3% Average SC-GHG case	2.4	54	58	72	73	100
2.5% Average SC-GHG case	3.1	63	69	85	86	123
3% 95th percentile SC-GHG case	4.9	88	96	117	119	183

C. Conclusion

When considering new or amended energy conservation standards, the standards that DOE adopts for any type (or class) of covered product must be designed to achieve the maximum improvement in energy efficiency that the Secretary determines is technologically feasible and economically justified. (42 U.S.C. 6295(o)(2)(A)) In determining whether a standard is economically justified, the Secretary must determine whether the benefits of the standard exceed its burdens by, to the greatest extent practicable, considering the seven statutory factors discussed previously. (42 U.S.C. 6295(o)(2)(B)(i)) The new or amended standard must also result in significant conservation of energy. (42 U.S.C. 6295(o)(3)(B))

For this final rule, DOE considered the impacts of new and amended standards for consumer water heaters at each TSL, beginning with the maximum technologically feasible level, to determine whether that level was economically justified. Where the max-tech level was not justified, DOE then considered the next most efficient level and undertook the same evaluation until it reached the highest efficiency level that is both technologically feasible and economically justified and saves a significant amount of energy.

To aid the reader as DOE discusses the benefits and/or burdens of each TSL, tables in this section present a summary of the results of DOE's quantitative analysis for each TSL. In addition to the quantitative results presented in the tables, DOE also considers other burdens and benefits that affect economic justification. These include the impacts on identifiable subgroups of consumers who may be disproportionately affected by a national standard and impacts on employment.

DOE also notes that the economics literature provides a wide-ranging discussion of how consumers trade off up-front costs and energy savings in the absence of government intervention. Much of this literature attempts to explain why consumers appear to undervalue energy efficiency improvements. There is evidence that consumers undervalue future energy savings as a result of (1) a lack of information; (2) a lack of sufficient salience of the long-term or aggregate benefits; (3) a lack of sufficient savings to warrant delaying or altering purchases; (4) excessive focus on the short term, in the form of inconsistent weighting of future energy cost savings relative to available returns on other investments; (5) computational or other difficulties associated with the evaluation of relevant tradeoffs; and (6) a divergence in incentives (for example, between renters and owners, or builders and purchasers). Having less than perfect foresight and a high degree of uncertainty about the future, consumers may trade off these types of investments at a higher than expected rate between current consumption and uncertain future energy cost savings.

In DOE's current regulatory analysis, potential changes in the benefits and costs of a regulation due to changes in consumer purchase decisions are included in two ways. First, if consumers forego the purchase of a product in the standards case, this decreases sales for product manufacturers, and the impact on manufacturers attributed to lost revenue is included in the MIA. Second, DOE accounts for energy savings attributable only to products actually used by consumers in the standards case; if a standard decreases the number of products purchased by consumers, this decreases the potential energy savings from an energy conservation standard. DOE provides estimates of shipments and changes in the volume of product purchases in chapter 9 of the final rule TSD. However, DOE's current analysis does not explicitly control for heterogeneity in consumer preferences, preferences across subcategories of products or specific features, or consumer price sensitivity variation according to household income.[184]

While DOE is not prepared at present to provide a fuller quantifiable framework for estimating the benefits and costs of changes in consumer purchase decisions due to an energy conservation standard, DOE is committed to developing a framework that can support empirical quantitative tools for improved assessment of the consumer welfare impacts of appliance standards. DOE has posted a paper that discusses the issue of

[184] P.C. Reiss and M.W. White. Household Electricity Demand, Revisited. *Review of Economic Studies*. 2005. 72(3): pp. 853–883. doi: *10.1111/0034-6527.00354*.

consumer welfare impacts of appliance energy conservation standards, and potential enhancements to the methodology by which these impacts are defined and estimated in the regulatory process.[185] DOE welcomes comments on how to more fully assess the potential impact of energy conservation standards on consumer choice and how to quantify this impact in its regulatory analysis in future rulemakings.

1. Benefits and Burdens of TSLs Considered for Consumer Water Heater Standards

Table V.33 and Table V.34 summarize the quantitative impacts estimated for each TSL for consumer water heaters. The national impacts are measured over the lifetime of consumer water heaters purchased in the 30-year period that begins in the anticipated year of compliance with amended standards (2030–2059). The energy savings, emissions reductions, and value of emissions reductions refer to full-fuel-cycle results. DOE is presenting monetized benefits of GHG emissions reductions in accordance with the applicable Executive Orders, and DOE would reach the same conclusion presented in this notice in the absence of the social cost of greenhouse gases, including the Interim Estimates presented by the Interagency Working Group because the consumer benefits alone outweigh the costs of the adopted rule (as described in section V.C). The efficiency levels contained in each TSL are described in section V.A of this document.

Table V.33 Summary of Analytical Results for Consumer Water Heater TSLs: National Impacts

[185] Sanstad, A. H. *Notes on the Economics of Household Energy Consumption and Technology Choice*. 2010. Lawrence Berkeley National Laboratory. *www1.eere.energy.gov/buildings/appliance_standards/pdfs/consumer_ee_theory.pdf* (last accessed July 1, 2021).

Category	TSL 1	TSL 2	TSL 3	TSL 4	TSL 5	TSL 6
Cumulative FFC National Energy Savings						
Quads	0.4	17.6	21.0	24.3	24.9	30.8
Cumulative FFC Emissions Reduction						
CO_2 (*million metric tons*)	22	332	379	448	462	803
CH_4 (*thousand tons*)	280	3,058	3,413	4,078	4,228	8,534
N_2O (*thousand tons*)	0.0	2.9	3.5	4.0	4.1	4.7
SO_2 (*thousand tons*)	0.1	90	109	126	128	127
NO_X (*thousand tons*)	61	665	742	886	919	1,851
Hg (*tons*)	0.0	0.6	0.8	0.9	0.9	0.9
Present Value of Benefits and Costs (*3% discount rate, billion 2022$*)						
Consumer Operating Cost Savings	2.9	124	148	173	179	212
Climate Benefits*	1.3	17	20	23	24	43
Health Benefits**	2.0	33	38	45	46	77
Total Benefits†	6.2	175	206	241	249	332
Consumer Incremental Product Costs‡	1.3	42	60	62	67	97
Consumer Net Benefits	1.5	82	88	111	111	115
Total Net Benefits	4.8	132	146	179	182	235
Present Value of Benefits and Costs (*7% discount rate, billion 2022$*)						
Consumer Operating Cost Savings	1.1	47	56	65	67	80
Climate Benefits*	1.3	17	20	23	24	43
Health Benefits**	0.7	12	13	16	16	27
Total Benefits†	3.1	76	88	104	107	149
Consumer Incremental Product Costs‡	0.7	22	30	32	34	50
Consumer Net Benefits	0.4	25	25	33	33	30
Total Net Benefits	2.4	54	58	72	73	100

Note: This table presents the costs and benefits associated with consumer water heaters shipped during the period 2030−2059. These results include benefits to consumers which accrue after 2059 from the products shipped during the period 2030−2059.
* Climate benefits are calculated using four different estimates of the SC-CO_2, SC-CH_4, and SC-N_2O. Together, these represent the global SC-GHG. For presentational purposes of this table, the climate benefits associated with the average SC-GHG at a 3-percent discount rate are shown; however, DOE emphasizes the value of considering the benefits calculated using all four sets of SC-GHG estimates. To monetize the benefits of reducing GHG emissions, this analysis uses the interim estimates presented in the *Technical Support Document: Social Cost of Carbon, Methane, and Nitrous Oxide Interim Estimates Under Executive Order 13990* published in February 2021 by the IWG.
** Health benefits are calculated using benefit-per-ton values for NO_X and SO_2. DOE is currently only monetizing (for NO_X and SO_2) $PM_{2.5}$ precursor health benefits and (for NO_X) ozone precursor health benefits, but will continue to assess the ability to monetize other effects such as health benefits from reductions in direct $PM_{2.5}$ emissions. The health benefits are presented at real discount rates of 3 and 7 percent. *See* section IV.L of this document for more details.
† Total and net benefits include consumer, climate, and health benefits. For presentation purposes, total and net benefits for both the 3-percent and 7-percent cases are presented using the average SC-GHG with 3-percent discount rate.
‡ Costs include incremental equipment costs as well as installation costs.

Table V.34 Summary of Analytical Results for Consumer Water Heater TSLs: Manufacturer and Consumer Impacts

Category	TSL 1	TSL 2	TSL 3	TSL 4	TSL 5	TSL 6
Manufacturer Impacts						
Industry NPV (*million 2022$*) (No-new-standards case INPV = $1,478.8)	1,470.3 to 1,484.2	1,203.4 to 1,506.9	1,087.2 to 1,438.9	1,058.6 to 1,447.6	1,000.7 to 1,447.5	769.2 to 1,473.5
Industry NPV (*% change*)	(0.6) to 0.4	(18.6) to 1.9	(26.5) to (2.7)	(28.4) to (2.1)	(32.3) to (2.1)	(48.0) to (0.4)

Consumer Average LCC Savings (2022$)						
GSWH	15	29	29	29	29	(285)
OSWH	123	141	141	141	141	141
Small ESWH (20 gal ≤ V_{eff} ≤ 35 gal and FHR < 51 gal)	NA	NA	(750)	(750)	(750)	(750)
ESWH (20 gal ≤ V_{eff} ≤ 55 gal excluding Small ESWH)	NA	859	859	1,146	1,067	1,067
ESWH (55 gal < V_{eff} ≤ 120 gal)	458	458	458	613	190	190
Shipment-Weighted Average*	15	429	340	472	458	251
Consumer Simple PBP (years)						
GSWH	8.4	9.1	9.1	9.1	9.1	18.5
OSWH	4.7	6.5	6.5	6.5	6.5	6.5
Small ESWH (20 gal ≤ V_{eff} ≤ 35 gal and FHR < 51 gal)	NA	NA	16.5	16.5	16.5	16.5
ESWH (≥20 gal and ≤55 gal excluding Small ESWH)	NA	5.6	5.6	5.0	5.2	5.2
ESWH (>55 gal and ≤120 gal)	0.2	0.2	0.2	0.5	1.4	1.4
Shipment-Weighted Average*	3.3	6.9	8.5	8.3	8.5	14.3
Percent of Consumers that Experience a Net Cost						
GSWH	20	41	41	41	41	70
OSWH	11	27	27	27	27	27
Small ESWH	0	0	77	77	77	77
ESWH (≥20 gal and ≤55 gal excluding Small ESWH)	0	35	35	33	38	38
ESWH (>55 gal and ≤120 gal)	0	0	0	1	39	39
Shipment-Weighted Average*	10	35	40	39	42	57

*Weighted by market share in start year of 2030.

DOE first considered TSL 6, which represents the max-tech efficiency levels for all product classes. At TSL 6, the design options for GSWHs include condensing technology; the design options for ESWHs include heat pump technology; and the design options for oil-fired storage water heaters ("OSWHs") include extra insulation and multi-flue heat exchangers. TSL 6 would require extensive changes to the way manufacturers currently produce water heaters. At TSL 6, approximately 2 percent of consumer water heater shipments are expected to meet the required efficiency levels by the 2030 compliance date. This includes approximately 0.2 percent of shipments for GSWHs, 17 percent of shipments for OSWHs, 1 percent of small ESWH, 5 percent of ESWH with an effective storage volume of less than 55 gallons (excluding small ESWH) shipments, and 11 percent of ESWHs with an effective storage volume greater than or equal to 55 gallons shipments. There would be a significant ramp up in manufacturing capacity, especially for gas storage and electric storage water heaters, needed to support the market due to the transition to accommodate these advanced technologies.

TSL 6 would save an estimated 30.8 quads of energy, an amount DOE considers significant. Under TSL 6, the NPV of consumer benefit would be $30 billion using a discount rate of 7 percent, and $115 billion using a discount rate of 3 percent.

The cumulative emissions reductions at TSL 6 are 803 Mt of CO_2, 8,534 thousand tons of CH_4, 4.7 thousand tons of N_2O, 1,851 thousand tons of NO_X, 127 thousand tons of SO_2, and 0.9 tons of Hg. The estimated monetary value of the climate benefits from reduced GHG emissions (associated with the average SC-GHG at a 3-percent discount rate) at TSL 6 is $43 billion. The estimated monetary value of the health benefits from reduced SO_2 and NO_X emissions at TSL 6 is $27 billion using a 7-percent discount rate and $77 billion using a 3-percent discount rate.

Using a 7-percent discount rate for consumer benefits and costs, health benefits from reduced SO_2 and NO_X emissions, and the 3-percent discount rate case for climate benefits from reduced GHG emissions, the estimated total NPV at TSL 6 is $100 billion. Using a 3-percent discount rate for all benefits and costs, the estimated total NPV at TSL 6 is $235 billion. The estimated total NPV is provided for additional information; however, DOE primarily relies upon the NPV of consumer benefits when determining whether a proposed standard level is economically justified.

At TSL 6, consumers will experience an average LCC cost of $285 for GSWHs, which is primarily driven by the total installed cost increases for gas condensing technology. For OSWHs, consumers will experience an average LCC savings of $141. For electric storage water heaters 20 to 35 gallons, consumers will experience an LCC cost of $750. For GSWHs, the consumers experiencing a net LCC cost is 70 percent, and for small ESWHs, the consumers experiencing a net LCC cost is 77 percent.

At TSL 6, the projected change in INPV ranges from a decrease of $709.5 million to a decrease of $5.2 million, which corresponds to a decrease of 48.0 percent and a decrease of 0.4 percent, respectively. The range of the impacts is driven primarily by the ability of manufacturers to recover their compliance costs. DOE estimates that industry must invest $626.2 million to comply with standards set at TSL 6. DOE understands that manufacturers would need to significantly upgrade their facilities to accommodate heat pump technology for ESWHs. Upgrades to produce heat pump electric storage water heaters include expansion of heat exchanger facilities and inclusion of refrigeration charging systems. In addition, manufacturers would need to expand their component sourcing of compressors and more sophisticated controls to produce these more advanced technology products. DOE estimates that manufacturers would need to scale up production of heat pump electric storage water heaters from approximately 3 percent of

ESWH sales today (0.14 million units in 2023) to 100 percent of ESWH units in 2030. DOE believes significant research and development efforts would also be needed to support the introduction of a wider variety of heat pump water heater models in the market to meet the various needs of consumers, especially split-system heat pump water heaters that would be needed to support the replacement of small electric storage water heaters. Currently, there are very limited split-system heat pump water heater models commercially available in the United States, which are produced by only a few manufacturers and are sold in low quantities. DOE is concerned that sufficient products may not be available to support the small electric storage water heaters market, and new products may not be introduced by a large majority of water heater manufacturers by the compliance date of this final rule. In sum, DOE is concerned that industry will not be able to transition to 100 percent of electric storage water heaters to heat pump designs within a 5-year compliance window, as would be necessary to comply with TSL 6.

DOE is also concerned about training the workforce that would be needed to install and service the heat pump water heater market by the compliance date of the standards. ESWHs are typically installed by plumbers. Advanced-technology water heaters require the ability to work with refrigerants similar to that of heating, ventilation, and air conditioning servicing contractors. DOE hopes that the emergence of workforce programs supported by the Inflation Reduction Act and the Bipartisan Infrastructure Law will begin to support the training and education of the workforce needed to support the clean energy transition. However, DOE understands this transition will take time and the workforce may not be ready at the scale necessary to support TSL 6.

The Secretary concludes that at TSL 6 for consumer water heaters, the benefits of energy savings, positive NPV of consumer benefits, emission reductions, and estimated monetary value of the emissions reductions would be outweighed by economic impacts to manufacturers, primarily driven by the ramp up in scale and offerings needed to support both ESWH and GWSH efficiencies at TSL 6, the economic costs for small ESWH consumers (many of whom are low income), and the distinct impact of high initial costs for low-income consumers purchasing replacement water heaters in emergency circumstances. Approximately 0.2 percent of gas storage water heater shipments and approximately 4 percent of all electric storage water heaters shipments would meet TSL 6 efficiencies by 2030. DOE also notes that new technologies have recently been introduced into the heat pump water heater market, such as 120-volt water heaters, whose efficiencies are lower than TSL 6. Such 120-volt water heaters can be more readily adopted by more households, lowering installation costs. While DOE expects continued innovation in the heat pump water heater market at this time, DOE is worried that prematurely requiring TSL 6 efficiency levels will remove these new products from the market prematurely. The Secretary is also concerned about the uncertainty in the market to ensure GSWHs and ESWHs will continue to be available to all consumers, including small ESWH replacements. Consequently, the Secretary has concluded that TSL 6 is not economically justified.

DOE then considered TSL 5, which represents the max-tech efficiency levels for all product classes except for GSWHs, which includes a lower non-condensing efficiency level. At TSL 5, the design options for GSWHs include either gas-actuated or electric flue dampers instead of condensing technologies. For the remainder of the product classes, the efficiency levels and technologies are the same as in TSL 6: that is, for ESWHs, TSL 5 includes max-technology efficiency levels for heat pump water heaters across all ESWH product classes, including small ESWHs. Approximately 14 percent of consumer water heater shipments are expected to meet the TSL 5 efficiency levels by the 2030 compliance date. The percentage of shipments expected to meet or exceed the efficiency levels in TSL 5 is the same as TSL 6 for all product classes except for GSWH. For GSWHs, approximately 23 percent of shipments are expected to meet TSL 5 efficiencies by the compliance date of the amended standards. At TSL 5, the standard would transition all consumer electric storage water heaters to heat pump technology across all effective storage volumes, delivery capacity offerings, and sizes in the market.

TSL 5 would save an estimated 24.9 quads of energy, an amount DOE considers significant. Under TSL 5, the NPV of consumer benefit would be $33 billion using a discount rate of 7 percent, and $111 billion using a discount rate of 3 percent.

The cumulative emissions reductions at TSL 5 are 462 Mt of CO_2, 4,228 thousand tons of CH_4, 4.1 thousand tons of N_2O, 919 thousand tons of NO_X, 128 thousand tons of SO_2, and 0.9 tons of Hg. The estimated monetary value of the climate benefits from reduced GHG emissions (associated with the average SC-GHG at a 3-percent discount rate) at TSL 5 is $24 billion. The estimated monetary value of the health benefits from reduced SO_2 and NO_X emissions at TSL 5 is $16 billion using a 7-percent discount rate and $46 billion using a 3-percent discount rate.

Using a 7-percent discount rate for consumer benefits and costs, health benefits from reduced SO_2 and NO_X emissions, and the 3-percent discount rate case for climate benefits from reduced GHG emissions, the estimated total NPV at TSL 5 is $73 billion. Using a 3-percent discount rate for all benefits and costs, the estimated total NPV at TSL 5 is $182 billion. The estimated total NPV is provided for additional information; however, DOE primarily relies upon the NPV of consumer benefits when determining whether a proposed standard level is economically justified.

At TSL 5, DOE estimates that consumers will see a life-cycle cost savings for all product classes, except for small ESWH. At TSL 5, the average LCC savings is $29 for GSWH consumers, which is driven by the lower installed costs as compared to the TSL 6 condensing level. While the LCC savings are positive for a majority of consumers across TSL 5 product classes, 77 percent of small ESWH consumers will experience a net cost when installing a split-system heat pump water heater.

At TSL 5, the projected change in INPV ranges from a decrease of $478.1 million to a decrease of $31.3 million, which corresponds to a decrease of 32.3 percent and a decrease of 2.1 percent, respectively. DOE estimates that industry must invest $387.6 million to comply with standards set at TSL 5. The primary driver of high conversion costs is the industry's investment to meet market demand for heat pump electric storage water heaters. DOE estimates that manufacturers would need to scale up production of heat pump electric storage water heaters from approximately 3 percent of all ESWH units (0.14 million units in 2023) to 100 percent of units in 2030. As a part of this scale-up, manufacturers would need to develop new split-system heat pumps for the small electric storage water heater market. Manufacturers would likely need to invest in cost optimization of existing designs, in new designs, and in additional manufacturing capacity for heat pump water heaters.

Similar to the discussion at TSL 6, DOE's concerns continue to be driven by the ramp up in manufacturing, research, and development that would be needed to support the heat pump water heater market to continue today's volumes. TSL 5 would require the expansion of heat pump lines and the introduction of new products to support the entire market, especially small ESWHs.

The Secretary concludes that at TSL 5 for consumer water heaters, the benefits of energy savings, positive NPV of consumer benefits, emission reductions, and estimated monetary value of the emissions reductions would be outweighed by the impacts on manufacturers, driven by the uncertainty in the ramp up needed to support a full transition of all volumes to heat pump water heaters for ESWHs, the impacts on consumers of small ESWHs, and the increase in initial costs. While the LCC savings are positive for a majority of consumers across TSL 5 product classes, 56 percent of small ESWH consumers would experience net costs when installing a split-system heat pump water heater. DOE is concerned about the increase in first costs for consumers forced to purchase a replacement water heater when their existing water heater fails and the inability for the market to introduce cost-optimized heat pump water heaters as an offering to consumers to help mitigate the initial first cost increase. As at TSL 5, DOE is also concerned about the workforce being ready to service and install at the volumes necessary to support such a transition in 5 years. Consequently, the Secretary has concluded that TSL 5 is not economically justified.

DOE then considered TSL 4, which represents a lower efficiency level for ESWHs and maintains the same efficiency levels for OSWHs and GSWHs as at TSL 5. At TSL 4, the design options for GSWHs include either gas-actuated or electric flue dampers; the design options for OSWHs include extra insulation and multi-flue heat exchangers; and the design options for ESWHs include heat pump technology. Approximately 17 percent of consumer water heater shipments are expected to meet the TSL 4 efficiency levels by the 2030 compliance date. The percentage of shipments in 2030 expected to meet the analyzed level in TSL 4 for ESWHs is approximately 11 percent, which is a significant increase from the max-tech efficiency levels required at TSL 5 and TSL 6. However, for small ESWH, the percentage of shipments expected to meet TSL 4 remains at approximately 1 percent. At TSL 4, the standard would transition all consumer electric storage water heaters to heat pump technology, but at a more moderate efficiency level for ESWHs except for small ESWHs. DOE still expects this transition to be significant, but DOE notes that manufacturers have more experience producing ESWHs, excluding small ESWHs, at these efficiency levels due to the prevalence of the ENERGY STAR program. DOE also expects the programs from the Inflation Reduction Act, including the appliance rebates and tax credits, would help support the expansion of this market.

TSL 4 would save an estimated 24.3 quads of energy, an amount DOE considers significant. Under TSL 4, the NPV of consumer benefit would be $33 billion using a discount rate of 7 percent, and $111 billion using a discount rate of 3 percent.

The cumulative emissions reductions at TSL 4 are 448 Mt of CO_2, 4,078 thousand tons of CH_4, 4.0 thousand tons of N_2O, 886 thousand tons of NO_X, 126 thousand tons of SO_2, and 0.9 tons of Hg. The estimated monetary value of the climate benefits from reduced GHG emissions (associated with the average SC-GHG at a 3-percent discount rate) at TSL 4 is $23 billion. The estimated monetary value of the health benefits from reduced SO_2 and NO_X emissions at TSL 4 is $16 billion using a 7-percent discount rate and $45 billion using a 3-percent discount rate.

Using a 7-percent discount rate for consumer benefits and costs, health benefits from reduced SO_2 and NO_X emissions, and the 3-percent discount rate case for climate benefits from reduced GHG emissions, the estimated total NPV at TSL 4 is $72 billion. Using a 3-percent discount rate for all benefits and costs, the estimated total NPV at TSL 4 is $179 billion. The estimated total NPV is provided for additional information; however, DOE primarily relies upon the NPV of consumer benefits when determining whether a proposed standard level is economically justified.

The average LCC across all product classes is positive, except for the small ESWH. DOE continues to be concerned about the development of new models that would need to be introduced into the split-system heat pump water heater market to support the small ESWH replacements. As DOE noted in discussing TSL 6, only a few manufacturers produce consumer water heaters today in very small volumes and would not be able to support the entire small ESWH market today. Similar to TSLs 5 and 6, 77 percent of small ESWH consumers will experience a net cost when installing a split-system heat pump water heater.

At TSL 4, the projected change in INPV ranges from a decrease of $420.1 million to a decrease of $31.2 million, which corresponds to a decrease of 28.4 percent and a decrease of 2.1 percent, respectively. DOE estimates that industry must invest $344.0 million to comply with standards set at TSL 4. For ESWH manufacturers, stepping down from max-tech provides greater flexibility in the design process and reduces the level of model-specific optimization. This results in lower conversion costs. However, manufacturers would still need to develop new split-system heat pumps for the small ESWH market and scale up production capacity for integrated heat pump water heaters. As previously discussed, DOE estimates that manufacturers would need to scale up production of heat pump electric storage water heaters from approximately 3 percent of ESWH sales in 2023 to 100 percent of units in 2030.

The Secretary concludes that at TSL 4 for consumer water heaters, the benefits of energy savings, positive NPV of consumer benefits, emission reductions, and estimated monetary value of the emissions reductions would be outweighed by the manufacturing concerns and by the uncertainty associated with the industry's ability to ramp up production at the levels necessary to meet a standard at TSL 4 within a 5-year period. Given TSL 4 represents a lower efficiency level that would require less model-specific optimization, DOE expects the research and development efforts to be smaller and DOE does expect significant ramp-up of this greater efficiency market segment in response to the incentive programs. However, DOE continues to be concerned about industry's ability to produce more than three million heat pump water heater units a year, while introducing new innovative products to meet consumers' needs and optimizing to produce lower-cost products. As at TSLs 6 and 5, DOE is concerned that the efficiency level required by TSL 4 may preclude the introduction of 120-volt water heaters into the broader market, which DOE considered as a qualitative factor and has considered in its decision-making. Adopting a standard level at TSL 4 would prevent innovation around these technologies (such as reducing their costs). Consequently, the Secretary has concluded that TSL 4 is not economically justified.

DOE then considered TSL 3, which represents the same levels as TSL 4 except includes a lower efficiency level for ESWHs. For those ESWHs less than 55 gallons of effective storage volume (including small ESWHs), TSL 3 includes an "entry" level heat pump efficiency level to accommodate some of the new product innovations that have been recently introduced into the market. At TSL 3, currently available 120-V heat pump water heaters would be able to comply with the required efficiencies. For ESWHs greater than 55 gallons of effective storage volume, TSL 3 includes an incremental increase in heat pump efficiency over the current standards. At TSL 3, the standard would still transition all consumer electric storage water heaters to heat pump technology. As previously noted, heat pump technology currently comprises approximately 3 percent of the electric storage water heater market. TSL 3 would shift 100 percent of electric storage water heaters to heat pumps, driving large investments in design of new heat pump offerings and new product capacity. Approximately 17 percent of consumer water heater shipments are expected to meet the TSL 3 efficiency levels by the 2030 compliance date. The percentage of shipments expected to meet or exceed the efficiency levels at TSL 3 is the same as TSL 4 for all product classes except for ESWHs. The percentage of shipments in 2030 expected to meet the analyzed level in TSL 3 for ESWHs is approximately 11 percent. However, for small ESWHs, the percentage of shipments expected to meet TSL 3 remains at approximately 1 percent in 2030.

TSL 3 would save an estimated 21.0 quads of energy, an amount DOE considers significant. Under TSL 3, the NPV of consumer benefit would be $25 billion using a discount rate of 7 percent and $88 billion using a discount rate of 3 percent.

The cumulative emissions reductions at TSL 3 are 379 Mt of CO_2, 3,413 thousand tons of CH_4, 3.5 thousand tons of N_2O, 742 thousand tons of NO_X, 109 thousand tons of SO_2, and 0.8 tons of Hg. The estimated monetary value of the climate benefits from reduced GHG emissions (associated with the average SC-GHG at a 3-percent discount rate) at TSL 3 is \$20 billion. The estimated monetary value of the health benefits from reduced SO_2 and NO_X emissions at TSL 3 is \$13 billion using a 7-percent discount rate and \$38 billion using a 3-percent discount rate.

Using a 7-percent discount rate for consumer benefits and costs, health benefits from reduced SO_2 and NO_X emissions, and the 3-percent discount rate case for climate benefits from reduced GHG emissions, the estimated total NPV at TSL 3 is \$58 billion. Using a 3-percent discount rate for all benefits and costs, the estimated total NPV at TSL 3 is \$146 billion. The estimated total NPV is provided for additional information; however, DOE primarily relies upon the NPV of consumer benefits when determining whether a proposed standard level is economically justified.

At TSL 3, the average LCC impact is a savings across all product classes, except for the small ESWH. Similar to TSLs 4, 5, and 6, 77 percent of small ESWH consumers will experience a net cost when installing a split-system heat pump water heater.

At TSL 3, the projected change in INPV ranges from a decrease of \$391.5 million to a decrease of \$39.8 million, which corresponds to a decrease of 26.5 percent and a decrease of 2.7 percent, respectively. DOE estimates that industry must invest \$332.4 million to comply with standards set at TSL 3. Manufacturers would need to develop new split-system heat pumps for the small ESWH market. They would also need to scale up production capacity for integrated heat pump water heaters.

The Secretary concludes that at TSL 3 for consumer water heaters, the benefits of energy savings, positive NPV of consumer benefits, emission reductions, and estimated monetary value of the emissions reductions would be outweighed by the uncertainty associated with the ability for industry to meet the demand necessary to support the entire market for ESWHs, including the workforce transition needed to service and install all of these heat pump water heaters. For small ESWHs, DOE estimates that the fraction of consumers experiencing a net cost is 56 percent. Based on those costs to small ESWH consumers and the possible difficulty of meeting the market needs within the compliance timeframe, the Secretary has concluded that TSL 3 is not economically justified.

DOE then considered TSL 2, which represents the baseline efficiency level for small ESWHs and heat pump efficiency levels for all other ESWHs. TSL 2 also includes max-tech efficiency levels for OSWHs and a moderate increase in efficiency for GSWHs. TSL 2 also aligns most closely with the Joint Stakeholder Recommendation efficiency levels, with minor differences to the small ESWH product class as discussed in section IV.C of this document. Approximately 24 percent of consumer water heater shipments are expected to meet the TSL 2 efficiency levels by the 2030 compliance date. The percentage of shipments expected to meet or exceed the efficiency levels at TSL 2 is the same as TSL 3 for all product classes except for small ESWHs. The percentage of shipments in 2030 expected to meet the TSL 2 efficiency levels for ESWHs is approximately 24 percent. However, since TSL 2 for small ESWHs represents the baseline efficiency level, all small ESWHs are expected to meet TSL 2 levels, compared to only 1 percent of small ESWH shipments at TSL 3. While DOE recognizes that TSL 2 is not the TSL that maximizes net monetized benefits, DOE has determined that TSL 2 is designed to achieve the maximum improvement in energy efficiency that is technologically feasible and economically justified.

TSL 2 would save an estimated 17.6 quads of energy, an amount DOE considers significant. Under TSL 2, the NPV of consumer benefit would be $25 billion using a discount rate of 7 percent and $82 billion using a discount rate of 3 percent.

The cumulative emissions reductions at TSL 2 are 332 Mt of CO_2, 3,058 thousand tons of CH_4, 2.9 thousand tons of N_2O, 665 thousand tons of NO_X, 90 thousand tons of SO_2, and 0.6 ton of Hg. The estimated monetary value of the climate benefits from reduced GHG emissions (associated with the average SC-GHG at a 3-percent discount rate) at TSL 3 is $17 billion. The estimated monetary value of the health benefits from reduced SO_2 and NO_X emissions at TSL 2 is $12 billion using a 7-percent discount rate and $33 billion using a 3-percent discount rate.

Using a 7-percent discount rate for consumer benefits and costs, health benefits from reduced SO_2 and NO_X emissions, and the 3-percent discount rate case for climate benefits from reduced GHG emissions, the estimated total NPV at TSL 2 is $54 billion. Using a 3-percent discount rate for all benefits and costs, the estimated total NPV at TSL 2 is $132 billion. The estimated total NPV is provided for additional information; however, DOE primarily relies upon the NPV of consumer benefits when determining whether a proposed standard level is economically justified.

At TSL 2, the average LCC impact is a savings for all product classes. The average LCC impact is a savings of $29 for GSWHs, savings of $141 for OSWHs, savings of $859 for ESWHs (20 gal ≤ V_{eff} ≤ 55 gal) excluding small ESWHs, and savings of $458 for ESWHs (55 gal < V_{eff} ≤ 120 gal). The fraction of consumers experiencing a net LCC cost is 41 percent for GSWHs, 27 percent for OSWHs, 35 percent for ESWHs (20 gal ≤ V_{eff} ≤ 55 gal) excluding small ESWHs, and 0 percent for ESWHs (55 gal < V_{eff} ≤ 120 gal). Consumers of small ESWH (20 gal ≤ V_{eff} ≤ 35 gal) are not impacted at TSL 2, as the standard is not proposed to be amended.

At TSL 2, the projected change in INPV ranges from a decrease of $275.3 million to an increase of $28.2 million, which corresponds to a decrease of 18.6 percent and an increase of 1.9 percent, respectively. DOE estimates that industry must invest $239.8 million to comply with standards set at TSL 2.

At higher TSLs, the primary driver of high conversion costs is the industry's investment to meet market demand for heat pump electric storage water heaters. TSL 2 preserves the existing market for small ESWHs, allowing small ESWHs utilizing only electric resistance technology (*i.e.*, that do not utilize a heat pump) to remain in the market. In turn, this reduces the level of investment needed to meet market demand for heat pump water heaters. DOE estimates industry would need to scale up production of heat pump electric storage water heaters from approximately 3 percent of ESWHs today to 61 percent of ESWHs in 2030, a significant reduction from higher TSLs. This approach, while still requiring a significant ramp up in manufacturing capacity for heat pump water heaters, allows for a more incremental transition to heat pump technology. It limits the investment required of manufacturers relative to higher TSLs that would require transitioning the entire ESWH market to heat pump technology and recognizes the benefits of providing additional time for small electric storage water heater designs using heat pump technology to mature. DOE believes that having a major manufacturer sign on to the Joint Stakeholder Recommendation is a testament to industry's ability to ramp up capacity to produce the volumes necessary to support the heat pump water heater market that will be required by TSL 2 by the compliance date of the amended standards.[186]

After considering the analysis and weighing the benefits and burdens, the Secretary has concluded that standards set at TSL 2 for consumer water heaters would be economically justified. At this TSL, the average LCC savings for consumers of all product classes are expected to be positive. The average LCC savings across all ESWH, excluding small ESWHs, consumers is $1,867. At TSL 2, the efficiency levels for ESWHs allow for continued development and innovation with 120-V heat pump ESWHs as well as split-system heat pump ESWHs. The efficiency levels at TSL 2 also allow for existing small ESWHs to remain on the market, providing an important option for a subset of consumers. The FFC national energy savings are significant and the NPV of consumer benefits is positive using both a 3-percent and 7-percent discount rate. These national benefits vastly outweigh the costs. The positive LCC savings—a different way of quantifying consumer benefits—reinforces this conclusion. The standard levels at TSL 2 are economically justified even without weighing the estimated monetary value of

[186] As detailed in II.B.2 of this document, Rheem is a signatory to the Joint Stakeholder Recommendation. BWC was an original signatory to the Joint Stakeholder Recommendation, which included a recommendation of heat pump levels for ESWHs with rated storage volumes greater than 35 gallons, but subsequently removed itself as a signatory after the July 2023 NOPR after raising concerns about how DOE proposed to align with the Joint Stakeholder Recommendation.

emissions reductions. When those emissions reductions are included—representing $17 billion in climate benefits (associated with the average SC-GHG at a 3-percent discount rate), and $12 billion (using a 7-percent discount rate) or $33 billion (using a 3-percent discount rate) in health benefits—the rationale becomes stronger still.

In addition, DOE considered that the efficiency levels across TSL 2 are generally representative of the Joint Stakeholder Recommendation. More specifically, DOE believes the Joint Stakeholder agreement from a cross section group of stakeholders provides DOE with a good indication of stakeholder views on this rulemaking and with some assurance that industry can transition to these levels and the market will see significant benefits, as indicated by DOE's analysis.

Accordingly, the Secretary has concluded that TSL 2 would offer the maximum improvement in efficiency that is technologically feasible and economically justified, and would result in the significant conservation of energy. Although results are presented here in terms of TSLs, DOE analyzes and evaluates all possible ELs for each product class in its analysis. TSL 2 comprises efficiency levels that offer significant LCC savings while keeping the percentage of consumers experiencing a net cost at a modest level. In particular, lower-income homeowners who currently use small ESWHs are significantly less likely to be disproportionately impacted at TSL 2 than at higher TSLs. TSL 2 also reduces the percentage of the market that would be transitioning to heat pump water heaters within a 5-year period. While DOE understands the ramp up to accommodate heat pump water heaters at TSL 2 is still significant, DOE believes manufacturers can leverage their existing operations, knowledge, workforce networks, and R&D to scale at a level needed to support an amended standard at TSL 2. Lastly, TSL 2 most closely represents the recommended standard levels submitted by Joint Stakeholders to DOE, providing further support for standard levels set at TSL 2, a factor the Secretary considers significant.

As discussed in section IV.F.9 of this document, DOE does not expect any significant amount of switching across product classes as a result of the adopted standards, with the exception of ESWHs and small ESWHs. There are a number of significant additional costs involved in switching from electric equipment to gas equipment and vice versa, such as replacing an electrical panel or installing new gas lines (both inside and outside of the home) and new venting. These additional costs can possibly exceed $1,000 on top of the installed costs estimated in this final rule, making product switching as a result of standards very likely to be a minimal effect at most.

Therefore, based on the above considerations, DOE adopts the conservation standards for consumer water heaters at TSL 2 for those product classes where there are existing applicable UEF standards. For the remaining product classes, DOE adopts converted standards in the UEF metric based on the amended appendix E test procedure. Altogether, the new and amended energy conservation standards for consumer water heaters, which are expressed as UEF, are shown in Table V.35. Note that this table does not show product classes for which standards remain unchanged by this final rule.

Table V.35 New and Amended Energy Conservation Standards for Consumer Water Heaters

Product Class	Effective Storage Volume and Input Rating* *(if applicable)*	Draw Pattern	Uniform Energy Factor
Gas-fired Storage Water Heater	< 20 gal	Very Small	$0.2062 - (0.0020 \times V_{eff})$
		Low	$0.4893 - (0.0027 \times V_{eff})$
		Medium	$0.5758 - (0.0023 \times V_{eff})$
		High	$0.6586 - (0.0020 \times V_{eff})$

Product Class	Effective Storage Volume and Input Rating* *(if applicable)*	Draw Pattern	Uniform Energy Factor
	≥20 gal and ≤55 gal	Very Small	0.3925 − (0.0020 × V_{eff})
		Low	0.6451 − (0.0019 × V_{eff})
		Medium	0.7046 − (0.0017 × V_{eff})
		High	0.7424 − (0.0013 × V_{eff})
	> 100 gal	Very Small	0.1482 − (0.0007 x V_{eff})
		Low	0.4342 − (0.0017 x V_{eff})
		Medium	0.5596 − (0.0020 x V_{eff})
		High	0.6658 − (0.0019 x V_{eff})
Oil-fired Storage Water Heater	≤50 gal	Very Small	0.2909 − (0.0012 × V_{eff})
		Low	0.5730 − (0.0016 × V_{eff})
		Medium	0.6478 − (0.0016 × V_{eff})
		High	0.7215 − (0.0014 × V_{eff})
	> 50 gal	Very Small	0.1580 − (0.0009 x V_{eff})
		Low	0.4390 − (0.0020 x V_{eff})
		Medium	0.5389 − (0.0021 x V_{eff})
		High	0.6172 − (0.0018 x V_{eff})
Very Small Electric Storage Water Heater	< 20 gal	Very Small	0.5925 − (0.0059 x V_{eff})
		Low	0.8642 − (0.0030 x V_{eff})
		Medium	0.9096 − (0.0020 x V_{eff})
		High	0.9430 − (0.0012 x V_{eff})
Small Electric Storage Water Heater	≥20 gal and ≤35 gal	Very Small	0.8808 − (0.0008 × V_{eff})
		Low	0.9254 − (0.0003 × V_{eff})
Electric Storage Water Heaters	≥20 and ≤ 55 gal (excluding small electric storage water heaters)	Very Small	2.30
		Low	2.30
		Medium	2.30
		High	2.30
	>55 gal and ≤120 gal	Very Small	2.50
		Low	2.50
		Medium	2.50
		High	2.50
	>120 gal	Very Small	0.3574 − (0.0012 x V_{eff})
		Low	0.7897 − (0.0019 x V_{eff})
		Medium	0.8884 − (0.0017 x V_{eff})
		High	0.9575 − (0.0013 x V_{eff})
Tabletop Water Heater	<20 gal	Very Small	0.5925 − (0.0059 x V_{eff})
		Low	0.8642 − (0.0030 x V_{eff})
	≥20 gal	Very Small	0.6323 − (0.0058 x V_{eff})
		Low	0.9188 − (0.0031 x V_{eff})
Instantaneous Oil-fired Water Heater	<2 gal and ≤210,000 Btu/h	Very Small	0.61
		Low	0.61
		Medium	0.61
		High	0.61
	≥2 gal and ≤210,000 Btu/h	Very Small	0.2780 − (0.0022 x V_{eff})
		Low	0.5151 − (0.0023 x V_{eff})
		Medium	0.5687 − (0.0021 x V_{eff})
		High	0.6147 − (0.0017 x V_{eff})
Instantaneous Electric Water Heater	≥2 gal	Very Small	0.8086 − (0.0050 x V_{eff})
		Low	0.9123 − (0.0020 x V_{eff})
		Medium	0.9252 − (0.0015 x V_{eff})
		High	0.9350 − (0.0011 x V_{eff})

2. Annualized Benefits and Costs of the Adopted Standards

The benefits and costs of the adopted standards can also be expressed in terms of annualized values. The annualized net benefit is (1) the annualized national economic value (expressed in 2022$) of the benefits from operating products that meet the adopted standards (consisting primarily of operating cost savings from using less energy), minus increases in product purchase costs, and (2) the annualized monetary value of the climate and health benefits.

Table V.36 shows the annualized values for consumer water heaters under TSL 2, expressed in 2022$. The results under the primary estimate are as follows.

Using a 7-percent discount rate for consumer benefits and costs and health benefits from reduced NO_X and SO_2 emissions, and the 3-percent discount rate case for climate benefits from reduced GHG emissions, the estimated cost of the standards adopted in this rule is $2,623 million per year in increased equipment costs, while the estimated annual benefits are $5,655 million in reduced equipment operating costs, $1,051 in monetized climate benefits, and 1,416 in monetized health benefits. In this case, the net benefit would amount to $5,499 per year.

Using a 3-percent discount rate for all benefits and costs, the estimated cost of the standards is $2,586 million per year in increased equipment costs, while the estimated annual benefits are $7,566 million in reduced operating costs, $1,051 million in monetized climate benefits, and $2,033 million in monetized health benefits. In this case, the net benefit would amount to $8,065 million per year.

Table V.36 Annualized Benefits and Costs of Adopted Standards (TSL 2) for Consumer Water Heaters

	Million 2022$/year		
	Primary Estimate	**Low-Net-Benefits Estimate**	**High-Net-Benefits Estimate**
3% discount rate			
Consumer Operating Cost Savings	7,566	7,078	8,065
Climate Benefits*	1,051	1,039	1,063
Health Benefits**	2,033	2,009	2,058
Total Benefits†	10,650	10,125	11,186
Consumer Incremental Product Costs‡	2,586	3,023	2,398
Net Benefits	8,065	7,102	8,788
Change in Producer Cashflow (INPV)‡‡	(28) - 3	(28) - 3	(28) - 3
7% discount rate			
Consumer Operating Cost Savings	5,655	5,294	6,024
Climate Benefits* (3% discount rate)	1,051	1,039	1,063
Health Benefits**	1,416	1,400	1,432
Total Benefits†	8,122	7,732	8,519
Consumer Incremental Product Costs‡	2,623	2,984	2,467
Net Benefits	5,499	4,748	6,052
Change in Producer Cashflow (INPV)‡‡	(28) – 3	(28) - 3	(28) - 3

Note: This table presents the costs and benefits associated with consumer water heaters shipped during the period 2030−2059. These results include consumer, climate, and health benefits that accrue after 2059 from the products shipped during the period 2030−2059. The Primary, Low Net Benefits, and High Net Benefits Estimates utilize projections of energy prices from the *AEO2023* Reference case, Low Economic Growth case, and High Economic Growth case, respectively. In addition, incremental equipment costs reflect a medium decline rate in the Primary Estimate, a low decline rate in the Low Net Benefits Estimate, and a high decline rate in the High Net Benefits Estimate. The methods used to derive projected price trends are explained in sections IV.F.1 and IV.F.4 of this document. Note that the Benefits and Costs may not sum to the Net Benefits due to rounding.

* Climate benefits are calculated using four different estimates of the global SC-GHG (see section IV.L of this notice). For presentational purposes of this table, the climate benefits associated with the average SC-GHG at a 3 percent discount rate are shown; however, DOE emphasizes the value of considering the benefits

calculated using all four sets of SC-GHG estimates. To monetize the benefits of reducing GHG emissions, this analysis uses the interim estimates presented in the *Technical Support Document: Social Cost of Carbon, Methane, and Nitrous Oxide Interim Estimates Under Executive Order 13990* published in February 2021 by the IWG.
** Health benefits are calculated using benefit-per-ton values for NO_X and SO_2. DOE is currently only monetizing (for SO_2 and NO_X) $PM_{2.5}$ precursor health benefits and (for NO_X) ozone precursor health benefits, but will continue to assess the ability to monetize other effects such as health benefits from reductions in direct $PM_{2.5}$ emissions. *See* section IV.L of this document for more details.
† Total benefits for both the 3-percent and 7-percent cases are presented using the average SC-GHG with 3-percent discount rate.
‡ Costs include incremental equipment costs as well as installation costs.
‡‡ Operating Cost Savings are calculated based on the life cycle costs analysis and national impact analysis as discussed in detail below. *See* sections IV.F and IV.H of this document. DOE's national impacts analysis includes all impacts (both costs and benefits) along the distribution chain beginning with the increased costs to the manufacturer to manufacture the product and ending with the increase in price experienced by the consumer. DOE also separately conducts a detailed analysis on the impacts on manufacturers (*i.e.*, manufacturer impact analysis, or "MIA"). *See* section IV.J of this document. In the detailed MIA, DOE models manufacturers' pricing decisions based on assumptions regarding investments, conversion costs, cashflow, and margins. The MIA produces a range of impacts, which is the rule's expected impact on the INPV. The change in INPV is the present value of all changes in industry cash flow, including changes in production costs, capital expenditures, and manufacturer profit margins. The annualized change in INPV is calculated using the industry weighted average cost of capital value of 9.6 percent that is estimated in the manufacturer impact analysis (*see* chapter 12 of the final rule TSD for a complete description of the industry weighted average cost of capital). For consumer water heaters, the annualized change in INPV ranges from -$28 million to $3 million. DOE accounts for that range of likely impacts in analyzing whether a trial standard level is economically justified. *See* section V.C of this document. DOE is presenting the range of impacts to the INPV under two scenarios: the Preservation of Gross Margin scenario, which is the manufacturer markup scenario used in the calculation of Consumer Operating Cost Savings in this table; and the Preservation of Operating Profit scenario, where DOE assumed manufacturers would not be able to increase per-unit operating profit in proportion to increases in manufacturer production costs. DOE includes the range of estimated annualized change in INPV in the above table, drawing on the MIA explained further in section IV.J of this document to provide additional context for assessing the estimated impacts of this final rule to society, including potential changes in production and consumption, which is consistent with OMB's Circular A-4 and E.O. 12866. If DOE were to include the INPV into the annualized net benefit calculation for this final rule, the annualized net benefits would range from $8,037 million to $8,068 million at 3-percent discount rate and would range from $5,471 million to $5,502 million at 7-percent discount rate.

3. Conversion Factor Final Rule Enforcement Policy

As discussed in section II.B.1 of this document, the currently applicable standards were established by the December 2016 Conversion Factor Final Rule, which utilized mathematical conversion equations to translate EF-based standards to the UEF metric for products that were on the market at the time. 81 FR 96204.

In that final rule, DOE issued an enforcement policy to ensure that individual models manufactured prior to July 13, 2015 that complied with the existing EF standards and remained unchanged in design would be tested to the EF metric and not be harmed by the transition to the UEF metric. 81 FR 96204, 96226-96227. This was done to prevent "overrating" to the minimum UEF standard; manufacturers are required to disclose the actual performance in the same metric as all other products. *Id.* The Department stated that these models will continue to remain subject to the enforcement policy until compliance with amended energy conservation standards is required. *Id.*

As a result, today's market continues to offer consumer water heaters that do not meet the current UEF-based standards (this is depicted in appendix 3A to the TSD). This final rule adopts amended energy conservation standards for consumer water heaters. Upon the compliance date of this final rule, the 2016 enforcement policy is terminated for all water heaters.

4. Severability

Finally, DOE added a new paragraph to 10 CFR 430.32 to make explicit the agency's intent that each energy conservation standard for each product class is separate and severable from one another, and that if any energy conservation standard for any product class is stayed or determined to be invalid by a court of competent jurisdiction, the remaining energy conservation standards for the other product classes shall continue in effect. Because this is an expression of DOE's intent, public comment on this paragraph is not relevant. This severability clause is intended to clearly express the Department's intent that should an energy conservation standard for any product class be stayed or invalidated, energy conservation standards for the other product classes shall continue in effect. In the event a court were to stay or invalidate one or more energy conservation standards for any product class as finalized, the Department would want the remaining energy conservation standards for the other product classes as finalized to remain in full force and legal effect.

D. Test Procedure Applicability

Manufacturers, including importers, must use product-specific certification templates to certify compliance to DOE. For consumer water heaters, the certification template reflects the general certification requirements specified at 10 CFR 429.12 and the product-specific requirements specified at 10 CFR 429.17. DOE has not proposed to amend the product-specific certification requirements for these products in this standards rulemaking. These requirements will be addressed in a separate rulemaking.

As discussed in section III.C of this document, DOE most recently amended the test procedure for these products at appendix E in the June 2023 TP Final Rule.

In light of the new and amended standards being adopted by this final rule, DOE is creating new provisions to specify how the appendix E test procedure should be applied. DOE is providing further clarifications around certain aspects of the appendix E test procedure to account for the products which would use this test procedure to determine UEF ratings. These amendments to the test procedure and related provisions are discussed in the following sections.

1. High-Temperature Testing

The current DOE test procedure calls for an outlet water temperature of 125 °F ± 5 °F. 88 FR 40406, 40422. This temperature is consistent with data DOE has on water heater thermostat settings in the field. For example, as discussed in chapter 7 of the final rule TSD, a 2015 study of 127 homes with electric resistance water heaters in central Florida showed that audited hot water setpoint temperatures averaged 127 °F (52.8 °C) (Std. Dev: 11.5 °F (6.4 °C)) and field measurement studies in California showed the median setpoint temperature to be 123 °F (50.6 °C). Additionally, as of 2017, survey data show that over 75% of contractors usually or always set the tank thermostat to 120 °F (*see* chapter 7 of the final rule TSD).[187] Further, the energy use analysis in this rulemaking uses water heater thermostat settings that are based on a 2006-2020 contractor survey conducted by Clear Seas.[188,189] This annual survey of more than 300 plumbing/hydronic heating contractor firms indicated that 41 percent of responding contractors *always* install a water heater with a setpoint temperature of 120 °F, 20 percent always install with a setpoint temperature higher than 120 °F, and 39 percent *usually* install with a setpoint of 120 °F. DOE assumed that half of the latter portion installed the water heater at 120 °F, resulting in an overall distribution of 61 percent of water heaters set to 120 °F, and 39 percent with setpoints uniformly distributed between 120 °F and 140 °F, resulting in an average setpoint of approximately 124 °F. In the July 2014 UEF TP Final Rule, DOE cited data that found the average set point temperature for consumer

[187] Clear Seas Research. 2017 Water Heater Study. *clearseasresearch.com* (Last accessed: Dec. 1, 2023).
[188] Clear Seas Research. Water Heater Study. 2006. Plumbing and Mechanical.
[189] Clear Seas Research. 2020 Water Heater Study, available online at: *clearseasresearch.com*. (Last accessed: May 1, 2023).

water heaters in the field is 124.2 °F (51.2 °C). 79 FR 40542, 40554. A compilation of field data across the United States and southern Ontario by Lawrence Berkeley National Laboratory had also found a median daily outlet water temperature of 122.7 °F (50.4 °C). *Id.* Taken together, these data indicate that the outlet water temperature of 125 °F ± 5 °F used in the DOE test procedure is representative of average water heater temperature settings in the field, with 120 °F being the most common setting.

However, after the December 2016 Conversion Factor Final Rule issued amended standards for electric storage water heaters with rated storage volumes above 55 gallons that could only be met through the use of heat pump technology, DOE observed a market shift towards smaller electric storage water heater sizes where the standards could be met through electric resistance heating. These smaller water heaters have a setting or mode that continuously stores water at a higher temperature then uses a mixing valve to deliver water at the temperature setpoint. As a result, a new market began to emerge for consumers who still desired effective storage volumes above 55 gallons but did not want to install heat pump water heaters: electric resistance storage water heaters with rated storage volumes less than 55 gallons but with significantly higher effective storage volumes due to higher storage tank temperatures. 88 FR 40406, 40446. DOE anticipates a similar market shift in response to this final rule as the new standards for electric storage water heaters with capacities greater than or equal to 20 gallons and less than or equal to 55 gallons are met through the use of heat pump technology, while the standards for small electric storage water heaters (capacities greater than or equal to 20 gallons and less than or equal to 35 gallons) can be met by electric resistance heating technology.

As stated in the July 2022 TP SNOPR and the June 2023 TP Final Rule, consumers would be expected to use the high-temperature mode on these small electric storage water heaters as part of the regular operation of their water heater because consumers are electing to purchase an undersized water heater based on its capacity-boosting ability. Accordingly, for such products, a representative average use cycle must encompass the "capacity boosting" capability, as this is the mode that the consumer will likely be using once the water heater is installed in the field. 88 FR 49058, 49164. However, before the June 2023 TP Final Rule, the DOE test procedure did not have a provision for measuring energy use of water heaters that continuously store water at a higher temperature to boost capacity. The June 2023 TP Final Rule established a high-temperature test method that would allow consumers to compare the energy efficiency of water heaters that increase capacity through elevated storage temperatures with water heaters that use larger tank volumes to achieve the same capacity. However, DOE deferred the implementation of high-temperature testing provisions to this energy conservation standards rulemaking. 88 FR 40406, 40448. This has allowed DOE to consider details of the implementation to best suit the needs of the market in a standards-case-scenario.

Whereas the June 2023 TP Final Rule established how to conduct a high-temperature test, this standards rulemaking establishes which products must use the high-temperature test method. In this final rule, DOE is adopting the proposed provisions for the application of the high-temperature test method, clarifying how the maximum tank temperature can be verified, adopting additional exemptions for very small and large electric storage water heaters, and permitting optional representations for heat pump water heaters using the high-temperature test method.

DOE received the following general comments in response to the July 2023 NOPR and December 2023 SNOPR regarding general support, applicability, and potential concerns around high-temperature testing and the use of effective storage volume. DOE also addresses information received regarding impacts associated with high-temperature testing.

The Joint Advocacy Groups supported DOE's proposed implementation of the effective storage volume and high temperature testing provisions, stating their agreement with DOE's determination that high-temperature testing is representative of the average use cycle for electric storage water heaters that offer consumers the ability to increase storage tank temperature. The Joint Advocacy Groups added that this proposal would also help ensure the expected savings from the proposed standards are realized. (Joint Advocacy Groups, No. 1165 at p. 7) NEEA supported DOE's proposed use of effective storage volume and high-temperature testing, asserting that it would effectively inhibit the use of small, overheated tanks installed with mixing valves as a means of circumventing heat pump-level standards, and would ensure the energy savings projected in the NOPR are realized. (NEEA, No. 1199 at pp. 7–8) CEC supported DOE's proposed high-temperature testing provisions, stating that they would close a significant loophole that would allow smaller, less-efficient storage water heaters to operate with higher effective storage volumes. (CEC, No. 1173 at p. 12) The Joint Stakeholders stated their support of the effective storage volume provisions, conditional on their narrow application to certain electric resistance storage water heaters, to aid in ensuring the expected savings from the proposed standards are realized.

The CA IOUs agreed that rated storage volume is no longer an appropriate measure for hot water service and supported the transition to using the effective storage volume metric, stating that such an approach is consistent with comments that they and others have provided previously in this rulemaking. The CA IOUs noted that only certain electric resistance storage water heaters would be subject to the high-temperature test method, and the effective storage volume would be equivalent to the rated storage volume for all other consumer water heaters. The CA IOUs recommended that DOE plainly state that high-temperature testing is applicable only for those electric storage water heaters with a maximum set point temperature above 135 °F, and that the effective storage volume for all other consumer water heaters is equal to the rated volume. (CA IOUs, No. 1175 at p. 2) The Joint Stakeholders also requested that DOE clarify the application of high-temperature testing and effective storage volume requirements with regards to product classes other than electric storage water heaters. (Joint Stakeholders, No. 1156 at pp. 1–2)

Rheem requested clarification on whether high-temperature testing is intended for electric instantaneous water heaters with rated storage volumes greater than or equal to 2 gallons. Rheem recommended that the high-temperature test method not apply to these products, as they are not direct replacements for heat pump water heaters. (Rheem, No. 1177 at p. 3)

To clarify, the high-temperature test method is applicable only to electric storage water heaters. It is not applicable to electric instantaneous water heaters. Consumer electric instantaneous water heaters, like consumer electric storage water heaters, are statutorily limited to an input rate of 12 kW (which corresponds to the typical household circuit limitations in residential buildings). (42 U.S.C. 6291(27)(A)–(B)) Instantaneous-type water heaters have at least 4,000 Btu/h of input per gallon of water stored. (42 U.S.C. 6291(27)(B)) Considering these two limitations, the maximum volume that a consumer electric instantaneous water heater could have is approximately 10 gallons. For the reasons detailed in section V.D.1.c of this document, products of this size are unlikely to use elevated temperatures to directly replace the consumer utility of a water heater with a larger stored volume of water. And, in response to the CA IOUs' request, DOE clarifies the verification of the maximum tank temperature in section V.D.1.b, which does more than simply state the applicability of the high-temperature test method is based on a maximum setpoint.

NYSERDA supported the use of the effective storage volume and the high-temperature test method, but noted that, although the high-temperature test applies only to certain electric storage water heaters, the appendix E test procedure would also result in an effective storage volume greater than rated storage volume for all other water heaters when $T_{max,1}$ is greater than 130 °F and also more than 5 °F higher than the delivery temperature, $T_{del,2}$.[190] NYSERDA therefore asked for clarification on how the

[190] $T_{max,1}$ is the maximum measured mean tank temperature after cut-out following the first draw of the 24-hour simulated-use test. $T_{del,2}$ is the average outlet water temperature during the 2nd draw of the 24-hour simulated-use test. See section 1.15 of appendix E.

effective storage volume metric is applied to different water heaters. (NYSERDA, No. 1192 at pp. 5–6, 7)

DOE is maintaining the provisions in appendix E, which result in a higher effective storage volume to products that have an internal tank temperature five degrees above the delivery set point temperature in order to assess products on an equivalent effective storage volume basis. As discussed in the June 2023 TP Final Rule, this would typically only apply if the product has a built-in mixing valve and normally operates in a manner that elevates the storage tank temperature in its default mode. Therefore, the increased effective storage volume is representative of the actual performance of such a model in its default mode. In the June 2023 TP Final Rule, DOE presented test data which demonstrated that only models with this specific design had effective storage volumes greater than rated storage volumes, and that all other traditional models of storage water heaters were unaffected.

GEA expressed support for DOE's proposals regarding high-temperature testing and the scope of products to which it would apply. GEA stated that DOE's proposed rule appropriately recognizes the importance of integrated mixing valves and accounts for them. However, GEA concurred with AHRI's comments regarding needed clarifications to the test procedure and standard and to the appropriate temperature limits for high-temperature testing (which are discussed in more detail later in this section). (GEA, No. 1203 at pp. 1–2)

Rheem agreed that the transition from electric resistance to heat pump storage water heaters presents an incentive to increase the temperature of an electric resistance storage water heater to increase the amount of hot water it can deliver. Rheem also stated that high-temperature testing should only be valid for products that operate with a stored volume of water (*i.e.*, storage-type or circulating). (Rheem, No. 1177 at p. 2) Relatedly, Rheem supported the application of the high-temperature test method to tabletop water heaters because these products can be used to replace heat pump water heaters. (Rheem, No. 1177 at p. 3)

Other commenters provided feedback for DOE to consider additional potential impacts of the high-temperature test method on the market. BWC stated that elements of the test procedure, such as the method for circulating water heaters and the application of high-temperature testing, appeared to be incomplete in the June 2023 TP Final Rule, and that DOE has continued to revise these aspects of the test procedure in the July 2023 NOPR. (BWC, No. 1164 at p. 7) AHRI raised concerns with the high-temperature test provisions for electric storage water heaters, stating that these provisions and their implications should have been fully addressed in the recent test procedure rulemaking because manufacturers require additional time to understand the proposal and how it would be implemented. AHRI stated that DOE has not provided clear direction in the July 2023 NOPR as to how the high-temperature test will be applied and enforced. (AHRI, No. 1167 at p. 2) AHRI and its members asserted that DOE has not provided sufficient test data for stakeholders to understand the impacts of the high-temperature test method on electric resistance storage water heaters. (AHRI, No. 1167 at p. 2)

A.O. Smith commented that the purpose of the high-temperature test method was to prevent circumvention of heat pump-level standards for larger electric storage water heaters by means of using a smaller electric resistance storage water heater operating at a higher temperature. A.O. Smith also noted that there may be additional avenues by which industry could avoid transitioning the market to heat pump water heaters. A.O. Smith recommended addressing these concerns in a supplemental NOPR prior to finalizing this rulemaking. A.O. Smith commented that understanding the relationship between maximum temperature offering, effective storage volume, FHR, and UEF is a prerequisite for evaluating the proposed efficiency levels for the electric storage water heater product classes. (A.O. Smith, No. 1182 at pp. 3–4)

A.O. Smith also asserted that DOE has not provided justification nor testing data to demonstrate that the direct substitution of effective storage volume instead of rated storage volume will make up for the known negative impact that testing at higher temperatures will have on UEF. Citing EPCA, A.O. Smith noted that DOE must account for the change in efficiency resulting from an amended test procedure and recommended that DOE test baseline very small and small electric storage water heaters according to the new test procedure to ensure that the proposed standards do not result in a stringency increase. To this end, A.O. Smith also provided its own test data, which demonstrate the reduction in UEF as a result of the high-temperature test method. A.O. Smith recommended that DOE adjust the standards to allow for these reduced ratings to remain compliant and minimize manufacturer redesign burden. (A.O. Smith, No. 1182 at pp. 3–4)

Rheem and A.O. Smith provided data that demonstrate the impact of high-temperature testing on these rated values for very small and small electric storage water heaters, while NEEA provided insights from its own testing regarding the relationship between temperature and FHR. (Rheem, No. 1177 at p. 21; A.O. Smith, No. 1182 at pp.

6-7) NEEA stated that the FHR increases by 2.5 gallons for every 5 °F increase in tank temperature from 125 °F. (NEEA, No. 1199 at pp. 7–8) Rheem stated that the boost in FHR from the high temperature will occur only for the first draw of the FHR test, and then afterwards the recovery rate will be the same, and the commenter provided an equation to estimate the increased FHR. (Rheem, No. 1177 at p. 21)

DOE reviewed the information from Rheem, A.O. Smith, and NEEA in addition to its own test data to evaluate the impact of the high-temperature test. For example, in the process of developing the June 2023 TP Final Rule, DOE collected data on one 50-gallon electric storage water heater set to three different tank temperature set points (one of them being the maximum setting that would be used for the high-temperature test method). 88 FR 40406, 40447.

The results of DOE's assessments on very small electric storage water heaters follow in section V.D.1.c of this document. DOE's calculations and data from stakeholders have led DOE to conclude that the high-temperature test method should not be required for very small electric storage water heaters.

In its own modeling analysis, Rheem identified that electric storage water heaters with rated storage volumes between 20 and 35 gallons would be noncompliant with the proposed standards if tested to the high-temperature test method, and therefore, all such products would have to be redesigned to use an exemption. (Rheem, No. 1177 at p. 2)

DOE has identified 35 certified basic models of small electric storage water heaters in its market assessment (*see* appendix 3A to the final rule TSD) and determined that all of these models heat water using electric resistance elements and, as currently designed, do not meet any of the criteria for an exemption to the requirement to determine UEF according to the high temperature test method. For example, most of these products are likely capable of heating and storing water at or above the temperature threshold criterion that would, if they were capable of only heating and storing water at that temperature or less, exempt them from high temperature testing (the temperature criterion is discussed in more detail in the following section of this document). (Heat pump small electric storage water heaters, discussed later in this paragraph, were not certified to DOE.) Based on the calculations provided by Rheem and NEEA, DOE has determined that the vast majority of these small electric storage water heaters are capable of achieving an FHR of more than 51 gallons when set to the highest temperature set point (as would be required under high-temperature testing), and thus these products would qualify for the medium draw pattern when tested to the high-temperature test method. As such, these products would be subject to the standards for electric storage water heaters under 55 gallons generally and not the standards for small electric storage water heaters, which are applicable only for products in the very small and low draw patterns. Further, the models that would remain in the low draw pattern (having an FHR less than 51 gallons) would have an effective storage volume greater than 35 gallons, such that they would not be considered small electric storage water heaters, either. Therefore, these specific small electric storage water heaters would be subject to standards being adopted for electric storage water heaters with 20-55 gallons of storage volume generally (*i.e.*, the standards for small electric storage water heaters would not apply), which are met through use of heat pump technology, unless they are redesigned to be eligible for one of the exemptions from high-temperature testing. If a product were redesigned to become eligible for an exemption, then the high-temperature test method would not be required, and thus these electric resistance products would remain as small electric storage water heaters and be subject to the standards being adopted for small electric storage water heaters, which can be met using electric resistance heating.

Additionally, in response to A.O. Smith's concern regarding the potential need to adjust small electric storage water heater standards to account for the impact of the high-temperature test, DOE notes that redesigns to the thermostat capabilities of electric storage water heaters are expected to be relatively low-cost for manufacturers, and products redesigned in such a manner would still be able to serve the majority of the market based on consumer field usage data (as described above). In a final rule amending test procedures for commercial water-heating equipment, DOE evaluated the implications of removing a temperature criterion of 180 °F that previously was part of the definition of a commercial water heater. 81 FR 79261, 79285 (Nov. 10, 2016). In that final rule, it was discussed that redesigning water heaters to account for the 180 °F temperature threshold can be achieved through replacement of a single part, the thermostat, which can be very easily and inexpensively changed to allow for heating water to greater than 180 °F. *Id.* In 2016 A.O. Smith commented that a thermostat designed to deliver water temperatures in excess of 180 °F can be installed at no additional cost on products that are consumer water heaters in all other respects. *Id.* (*See also* A.O. Smith, Docket No. EERE-2014-BT-TP-0008, No. 27 at pp. 6-7). In light of these previous stakeholder comments there is no reason to believe that, for small electric storage water heaters, redesigning models to limit the temperature to 135 °F would increase the price of the product. Hence, DOE expects thermostat redesigns to become a common strategy for manufacturers to offer small electric storage water heaters after the compliance date of this final rule.

However, this does not mean that all small electric storage water heaters available today would require redesign to be compliant with the amended standards set forth in this final rule. As discussed in section V.D.1.d of this document, the high-temperature test method is not required for heat pump water heaters; therefore, the high-temperature test method would not affect heat pump configurations on the market today. For example, consumers can continue to use circulating heat pump water heaters in small electric storage water heater configurations (*i.e.*, with small separate tanks) for cases where a small electric storage water heater is desired but without the specific design exemptions that electric resistance products would require. DOE has identified four recent models on the market—two of which have been marked for sale in the United States— which offer this capability.[191]

Consequently, DOE concludes that no compliant products on the market today will be required to use the high-temperature test method in order to demonstrate compliance with the standards being adopted in this final rule. Therefore, DOE is not establishing any specific enforcement provisions beyond the requirements of the appendix E test procedure with regards to the high temperature test method.

DOE recognizes that there may be additional ways for industry to develop alternatives to heat pump water heaters for consumers; however, DOE aims to have all

[191] Product literature for models of heat pump small electric storage water heaters can be found docketed at www.regulations.gov/docket/EERE-2017-BT-STD-0019. In the December 2023 SNOPR the Department had erroneously stated that there are no longer heat pump circulating water heaters available on the market (*see* 88 FR 89330, 89333) due to changes in a manufacturer's website.

products that offer the same performance, capacity, and consumer utility be treated equally under standards. The development and implementation of the high-temperature test method is one way to assure this for products that vary temperature to accomplish these ends. In addition to this, DOE is amending the definitions of the product classes to more accurately capture the branches of the market under which performance, capacity, and consumer utility can be grouped. This is discussed in section IV.A.1.e of this document.

PHCC commented that the storage temperature cannot be raised beyond the ability of a mixing valve to safely regulate the outlet water temperature, and that mixing valves are not inexpensive. PHCC asserted that the device itself can be 25 percent to 30 percent of the cost of the water heater itself, and along with additional labor, material, maintenance, and operational costs, which the commenter suggested would result in mixing valves not being a commonly used solution today. PHCC also warned that installation of water heaters at elevated temperatures without a mixing valve causes a serious safety risk in addition to increased standby losses. In its comment, PHCC stated that the creation of the limited capacity will almost ensure that the high-temperature outcomes will happen, and if so, DOE should consider mandating mixing valves to ensure safety for consumers. (PHCC, No. 1151 at p. 2)

The price of a mixing valve and its installation would vary depending on whether the mixing valve is shipped with the water heater, built into the water heater, or part of a standard installation kit. DOE understands the estimate of a mixing valve being 25 to 30 percent of the water heater's material price may reflect a separately purchased mixing valve. However, as discussed throughout this rulemaking and the most recent test procedure rulemaking, water heaters with built-in mixing valves or with mixing valves in the water heater's installation kit could become more common. Based on DOE's teardown analyses (as described in section IV.C.1.c of this document and chapter 5 of the final rule TSD), mixing valves that are provided by the water heater manufacturer could be significantly less expensive than ones purchased separately due to the volume in which water heater manufacturers can supply these. In the LCC analysis, DOE uses an estimate of approximately $75 per unit material price (before markup) based on the aforementioned teardown analyses assuming that the mixing valve can likely be provided by the water heater manufacturer in a scenario with amended standards.

While DOE agrees with PHCC that mixing valves are a safety feature and should be used to temper extra-hot water to a degree that does not pose such a high scalding risk, the Department notes that EPCA does not delegate DOE the authority to issue regulations mandating such a consumer safety feature. Instead, DOE is statutorily obligated to ensure that its energy conservation standards can be met by products that are safe for consumers (see the screening analysis criteria in section IV.B). In its analysis of amended standards for consumer water heaters in this final rule, DOE has determined that the standards for small electric storage water heaters can be met by products that either limit the high temperature capability or are compatible with mixing valves in order to protect consumers from scalding.

Therefore, as stated earlier, in this final rule, DOE is adopting the proposed provisions for the high-temperature test method, clarifying how the maximum tank temperature can be verified, adopting additional exemptions for very small and large electric storage water heaters, and permitting optional representations for heat pump water heaters using the high-temperature test method.

a. Maximum Tank Temperature

In the July 2023 NOPR, DOE proposed that certain water heaters that have a maximum setpoint temperature capable of heating and storing water above 135 °F would be required to conduct the high temperature test, while water heaters that can only heat and store water at or below 135 °F would not be required to undergo such testing. 88 FR 49058, 49165. In arriving at the 135 °F setpoint, DOE considered: (1) the effective storage volume of a small electric storage water heater with a rated storage volume of 35 gallons for various mean tank temperatures; and (2) potential consumer uses for higher storage tank temperatures. *Id.* The effective storage volume at various temperatures provides insight into the likelihood a small electric storage water heater would operate in a capacity-boosting mode, and in the July 2023 NOPR the Department provided a table that showed the effective storage volume for various tank temperature settings. Table V.37 from the July 2023 NOPR is reproduced here also. *Id.*

Table V.37 Effective Storage Volume of a Water Heater with a 35-gallon Rated Storage Volume at Various Mean Tank Temperatures

Mean Tank Temperature (°F)	V_{eff} of Water Heater with 35-gallon V_r (gallons)
125	35
130	38
135	41
140	44
145	47
150	50
155	53
160	56
165	59

170	62

For instance, it is unlikely a consumer would purchase a 35-gallon small electric storage water heater and set the tank temperature to 130 °F to increase the effective storage volume to 38 gallons, which is less than a 9 percent increase in effective storage volume. On the other hand, at a maximum setpoint of 140 °F, a 35-gallon small electric storage water heater could replace up to a 44-gallon heat pump water heater, which represents more than a 25 percent increase in effective capacity. *Id.* The market share of medium electric storage water heaters around 40 gallons is approximately 40 percent. As a result, DOE proposed a maximum temperature setpoint of 135 °F.

However, DOE also recognizes that increased capacity is not the only reason a consumer may want a higher tank storage temperature. Higher temperature setpoints can allow consumers to pair water heaters with clothes washers or dishwashers that lack heating elements and can be used to reduce bacterial growth. While the data shows that only a small percentage of consumers are utilizing tank temperature setpoints greater than 135 °F, DOE notes that the 135 °F maximum temperature setpoint is not a temperature limit. There are heat pump models of small electric water heaters available on the market that are exempt from the high temperature testing provisions and have temperature setpoints of 140 °F or higher.[192] Additionally, DOE proposed that units capable of storing water at a setpoint above 135 °F only through a temporary, consumer-initiated

[192] Product literature for models of heat pump small electric storage water heaters can be found docketed at www.regulations.gov/docket/EERE-2017-BT-STD-0019. See, for example, models marketed to reach up to 145 °F: *www.nyle.com/wp-content/uploads/2023/01/SB-E008T-010323.pdf* and www.heatwater.com/wp-content/uploads/2021/09/SB-C6-112923.pdf (Last accessed Jan. 18, 2024).

mode lasting no longer than 120 hours would not be subject to high temperature testing. This would allow consumers to initiate the temporary, high-heat mode prior to using a clothes washer or dishwasher that lacks a heating element for special cleaning loads, e.g., when dust mites or norovirus may be of particular concern. This temporary mode would also allow consumers to periodically raise the temperature of the tank past 135 °F to quickly eliminate any bacteria growth in the tank. For instance, if a consumer shuts their water heater off or puts it into a low-temperature vacation mode to conserve energy while not in use, they can use the temporary, high-heat mode to quickly eliminate any bacteria in the tank. Finally, DOE also notes that a setpoint of 135 °F is well within the range of many recommendations for controlling bacteria growth in storage water heaters.[193]

In response to the July 2023 NOPR, the Joint Advocacy Groups supported the proposed 135 °F threshold for high temperature testing provisions, adding that a threshold of 140 °F could significantly undermine the intent of the proposed standards by allowing 35-gallon water heaters to reach an effective storage volume of 44 gallons without being tested in a representative manner. The Joint Advocacy Groups also agreed with DOE's tentative determination that the proposed 135 °F threshold would not compromise the utility of the water heater for consumers who desire hotter water for certain situations. (Joint Advocacy Groups, No. 1165 at pp. 7–8) NEEA also urged DOE not to set the limit to require high-temperature testing any higher than 135 °F. (NEEA, No. 1199 at pp. 7–8)

[193] According to the CDC, legionella generally grow well between 77 °F and 113 °F, but growth slows between 113 °F and 120 °F, and legionella begin to die above 120 °F. See the CDC's Legionella Environmental Assessment Form. Centers for Disease Control and Prevention. Available online at *www.cdc.gov/legionella/downloads/legionella-environmental-assessment-p.pdf*. (Last accessed: Jan. 18, 2024).

BWC, on the other hand, urged DOE to consider increasing the temperature criterion for the high-temperature test exemption from 135 °F to 140 °F because residential electric storage water heaters that heat water to 140 °F serve a distinct health and safety function, as the Centers for Disease Control ("CDC") recommends maintaining this temperature to mitigate the formation or presence of legionella bacteria. (BWC, No. 1164 at p. 9) AHRI also suggested that the temperature criterion for the high-temperature test exemptions be increased to 140 °F because setting the internal tank temperature to 140 °F may produce significant health and safety benefits to consumers (*i.e.*, killing legionella, norovirus, and dust mites). AHRI provided information that showed that washing clothes and bedding at 140 °F is one of the suggested guidelines that healthcare agencies provide to kill dust mites and norovirus. Additionally, AHRI cited information from the CDC, which recommends storing hot water above 140 °F to control for legionella. (AHRI, No. 1167 at p. 3–4)

A.O. Smith similarly commented that a temperature of 140 °F is recommended to wash bedding and linens to kill dust mites and norovirus. The commenter also referenced DOE's website, which recommends that people with suppressed immune systems may want to keep their tank temperature at 140 °F and install limited devices on taps and baths. A.O. Smith stated that several codes, including the National Plumbing Code of Canada,[194] require electric resistance storage water heaters to be shipped at a 140 °F set point; therefore, allowing a 140 °F set point would reduce manufacturer burden from having to produce separate model lines for the United States and Canada. (A.O. Smith,

[194] National Plumbing Code of Canada 2020, page 200. Available online at: *nrc-publications.canada.ca/eng/view/ft/?id=6e7cabf5-d83e-4efd-9a1c-6515fc7cdc71r*. (Last accessed: Oct. 31, 2023)

No. 1182 at p. 6) A.O. Smith collected data on water heater temperatures from a survey of 500 homeowners. The data, A.O. Smith stated, showed that 63 percent of respondents adjusted the water heater set point from the factory-shipped temperature.[195] Of those who adjusted the set point, 45 percent increased the set point, 38 percent decreased the set point, and 17 percent had done both. A.O. Smith also gathered data from 40-gallon "connected" water heaters[196] which showed that a total of 10 percent of customers have set the temperature higher than 135 °F, whereas 5 percent of customers have the temperature higher than 140 °F. A.O. Smith argued that it believes a threshold of 140 °F for exemption from high-temperature testing better maintains consumer utility. (A.O. Smith, No. 1182 at p. 6)

Rheem noted that the EF test procedure, which had been in use for over 25 years, had a representative nominal tank temperature between 130 and 140 °F, so a temperature of 140 °F is representative for a subset of water heaters in the field today. Rheem stated that, in addition to requirements in Canada, the CDC also recommends temperature control limits that store hot water above 140 °F. (Rheem, No. 1177 at p. 4)

Finally, the CA IOUs strongly recommended that the temperature criterion for the high-temperature test method exemptions be reduced to no more than 130 °F. The CA

[195] DOE notes that clause 23.3 of UL Standard 174, "Household Electric Storage Tank Water Heaters," was recently updated to require that the temperature-regulating control shall be set before leaving the factory to a control position corresponding to a water temperature no higher than 51.7 °C (125 °F). When the water heater is equipped with a thermostatic mixing valve in addition to the temperature regulating control, the factory setting of the water temperature mixing valve shall be no higher than 51.7 °C (125 °F), and the temperature-regulating control shall be factory set no higher than 60 °C (140 °F). These updates went into effect on October 14, 2023. This standard can be accessed online at: *www.shopulstandards.com/ProductDetail.aspx?productId=UL174_11_S_20040429*. (Last accessed: Nov. 30, 2023).

[196] A.O. Smith did not specify whether these units were connected to a utility demand-response program or were otherwise equipped with WiFi-enabled controls and monitoring.

IOUs expressed concern that a temperature as high as 135 °F would still enable small electric storage water heaters to directly compete with a larger heat pump water heaters and erode the anticipated savings from heat pump-level standards. The CA IOUs calculated that if a lowboy water heater with 35 gallons of rated storage volume and a 51-gallon FHR were to operate at 135 °F with a thermostatic mixing valve, it would have an effective storage volume of 42 gallons and a new FHR of 56 gallons—which would appear to be in the range of the 20–55 gallon electric storage water heater class. Therefore, the CA IOUs stated that the high-temperature test should be required for electric storage water heaters that have a permanent mode or setting in which the water heater is capable of heating and storing water above the test procedure design temperature of 125 °F. (CA IOUs, No. 1175 at pp. 3-4)

First, in response to A.O. Smith's concern about manufacturer burden, DOE notes that harmonizing the factory-shipped setpoint temperature between the United States and Canada may not eliminate manufacturer burden. Specifically, the current minimum efficiency requirements for electric resistance storage water heaters are different in Canada, and several manufacturers currently offer distinct models in Canada to meet these requirements. *See* chapter 3 of the final rule TSD for more details on Canada's minimum efficiency requirements.

With respect to the comments on both raising and lowering the maximum setpoint temperature proposed in the July 2023 NOPR, DOE first notes that the maximum setpoint temperature is based on the expected use for these products. Data show that consumers do not generally use very high temperature setpoints even in light of CDC guidance, so the “upper limit” of temperatures found in normal installations appears to be lower than the 140 °F suggested by some stakeholders.

In the July 2023 NOPR, DOE tentatively determined that small electric storage water heaters that can heat and store water above 135 °F will be substantially more likely to be used permanently at higher temperatures to increase capacity (as discussed in section V.D.1 of this document). Commenters advocating for a higher maximum setpoint temperature of 140 °F do not dispute DOE’s determination that small electric storage water heaters that can heat and store water above 135 °F will be substantially more likely to be used permanently at higher temperatures to increase capacity. Instead, they focus on the health and safety benefits of setting the tank temperature to 140 °F. DOE recognizes that higher temperatures, *e.g.*, 140 °F, can more quickly control bacterial growth in storage water heaters. But, as discussed previously, DOE is not limiting the maximum temperature setpoint for small electric water heaters. Based on DOE’s and A.O. Smith’s data, approximately 10% of consumers use a setpoint temperature greater than 135 °F. For these consumers who prefer setpoint temperatures greater than 135°F, there are small electric heat pump water heaters on the market today that have setpoint temperatures above 140 °F, and these models would not be affected by the high-temperature testing provision. Further, as noted earlier, the temporary mode exemption will allow owners of electric resistance storage water heaters to periodically increase the temperature above 135 °F, and for up to 120 hours (or five days) at a time, if desired for short-term disinfection applications.

With respect to the comment from the CA IOUs that DOE lower the temperature to 130 °F, DOE thinks it is unlikely that a consumer would purchase a 35 gallon small electric water heater and operate it at 130 °F to increase the capacity by 3 gallons. While Rheem suggested that DOE refer to the outdated EF test procedure to determine what temperatures are considered typical, the current UEF test procedure can provide more recent insight. The current test method is based on a normal delivery temperature of 125 °F ± 5 °F (as discussed previously), and within this normal range, consumer storage-type water heaters may sometimes contain water at 130 °F due to natural deviations from the setpoint temperature.

For example, commercially available electric storage water heaters that are marketed today to boost the capacity using higher storage tank temperatures all do so with temperatures above 135 °F. One product tested by DOE has a “High” setting that results in a tank temperature of about 140 °F, and the setting below that resulted in a tank temperature of 125 °F. There was no setting observed to boost capacity at a tank temperature of 135 °F. Another manufacturer offers a 55-gallon product with a variety of settings allowing the user to get “performance equivalency” of a 65-, 80-, or 100-gallon tank, stating that the tank raises the temperature safely up to 170 °F. 88 FR 40406, 40446. At the lowest level of capacity boosting, this model is offering 18 percent additional effective storage volume (going from 55 gallons to 65 gallons), which would indicate a temperature around 140 °F as well. These designs demonstrate that storing water at 140 °F is a useful temperature for boosting capacity, whereas 135 °F may not be.

Crystal also recommended that DOE review the allowed usage of germicidal UV-C water treatment in recirculating hot- and warm-water lines to complement or substitute thermal disinfection cycles. According to Crystal, this is allowed under regulation in several countries around the world, and therefore products and research are available on the market as well as ongoing novel technology adoptions improving the sustainability and energy efficiency and maintenance of this field further. (Crystal, No. 577 at p. 1)

DOE has not found examples of consumer water heaters using UV treatment to disinfect hot water lines. However, to address issues like this, one manufacturer produces a point-of-use water heater that uses ozone generation to disinfect the water in the pipes and at the faucet while still delivering hot water at a temperature that is comfortable for hand-washing (the unit is advertised to have a maximum set point temperature of 120 °F).[197] Additionally, circulating water heaters (discussed more in section IV.A.1.a of this document) are a type of storage water heater that can maintain the water in the pipes at a high temperature so that all of the water in the system stays at a safe temperature and does not stagnate. The high temperature test will not impede the function of either of these types of products, as discussed later. Another manufacturer uses an antimicrobial enamel coating inside the water heater tank to prevent the growth of bacteria, mold, and mildew on the surface of the tank lining (though it is not advertised to specifically prevent legionella growth).[198]

b. Verification of Maximum Tank Temperature

As discussed in the previous section, in the July 2023 NOPR, DOE proposed that products that are unable to heat and store water at a set point above 135 °F would not be required to test using the high-temperature test method. 88 FR 49058, 49165. DOE received the following comments in response to the July 2023 NOPR requesting

[197] For more information, see product literature available online at: *www.intellihot.com/wp-content/uploads/2023/01/Legionator-Product-Spec-Sheet-2.23.pdf*. (Last accessed: Nov. 28, 2023).
[198] For more information, see product press release available online at: *www.microban.com/bradford-white*. (Last accessed: Nov. 29, 2023).

clarification on the maximum tank temperature, how it is measured, and specific tolerances around required values as well as criteria for products exempt of the high-temperature test method.

BWC asked for DOE to further clarify what design factors would constitute a product that is not capable of heating and storing water above 135 °F. Specifically, BWC sought additional information on whether the exemption criteria would be based on a direct user interface function which operates the product or, instead, a thermostat capable of being set above 135 °F. The commenter provided examples of configurations with surface-mount thermostats and electronic controls, with and without mixing valves, to inquire whether these configurations would be exempt from the high temperature test. (BWC, No. 1164 at pp. 7–8)

AHRI asked DOE to elaborate on how it would enforce the high-temperature test method. The commenter stated that most electric storage water heaters utilize a surface-mount thermostat, which is unsophisticated and has a large temperature tolerance—as a result, the mean tank temperature may vary appreciably from the temperature set point. AHRI stated that the mean tank temperature will typically be lower than the thermostat setting. As a result, AHRI requested feedback on whether the enforcement of the high-temperature test method would be based on thermostat set points or on test data (in the case that it is test data, AHRI recommended a temperature tolerance of ± 5 °F on $T_{max,1}$ prior to requiring high-temperature testing in appendix E). AHRI recommended that DOE measure the maximum tank temperature using the $T_{max,1}$ measurement in the simulated-use test because it is commonly used in the industry to evaluate the effective storage volume and is referenced in the regulations already (manufacturers and labs are familiar with how to test for $T_{max,1}$, and there would be minimal burden associated with determining the tank temperature based on this metric). (AHRI, No. 1167 at p. 4)

A.O. Smith also requested that DOE clarify how the temperature criterion for the high-temperature test is determined—whether it is a set point or whether it is a measurement. A.O. Smith stated that additional specificity is necessary because most electric resistance storage water heaters on the market use mechanical controls (*e.g.*, bi-metallic thermostats) which turn the elements on and off, resulting in larger temperature variation around the set point. A.O. Smith also requested that DOE clarify the enforcement provisions surrounding the level of external consumer intervention required to be exempt from the high-temperature test. (A.O. Smith, No. 1182 at p. 5)

Rheem requested clarification on how the maximum temperature a water heater is capable of storing water at is measured (whether it be the maximum temperature on the thermostat settings, the maximum temperature within the tank, the maximum mean tank temperature, or the maximum outlet temperature as measured by a test in section 29 of UL 174-2021.6[199]. Rheem recommended the use of $T_{max,1}$ to verify the temperature that a water heater can heat and store water to. (Rheem, No. 1177 at p. 5) Rheem recommended that DOE require certification and disclosure in product literature of the maximum temperature, FHR, and UEF when tested to the high-temperature requirements. Rheem also recommended that DOE establish enforcement provisions to ensure the maximum temperature aligns with the certified values. Rheem commented that a tolerance of ± 5 °F for the maximum tank temperature and ± 3 percent on the effective

[199] See UL 174-2021.6, UL Standard for Safety Household Electric Storage Tank Water Heaters

storage volume would be necessary due to variability in the test procedure and the imprecise operation of bi-metallic thermostat controllers. Rheem also asked for clarification on how DOE would conduct enforcement testing, and if DOE will run tests at both temperature conditions, then what steps must be taken between the two simulated-use tests. (Rheem, No. 1177 at p. 6)

In response to these requests for clarification, DOE clarifies that the exemption will be determined based on $T_{max,1}$, which is a measured parameter in the current test procedure that represents the maximum measured mean tank temperature after cut-out following the first draw of the 24-hour simulated-use test. In order to develop product-specific enforcement provisions for the high-temperature test method, DOE must first identify whether manufacturers should certify this value privately; as such, a certification was not suggested in the July 2023 NOPR. DOE is deferring this determination to a separate rulemaking addressing certification and enforcement provisions for consumer water heaters and is not codifying any specific requirements in this final rule.

In addition to this topic, Rheem suggested that, instead of conducting the high-temperature test at the maximum tank temperature, the high-temperature test should be conducted at a standardized temperature. Rheem recommended that the high-temperature test be performed at 160 °F ± 5 °F as a representative temperature for this type of water heater operation by 2029. Rheem stated that 160 °F is in between the 135 °F temperature criterion and the 180 °F maximum temperature (given that UL 174-2021 safety standard limits the maximum tank temperature to 185 °F). Rheem commented that future demand-response programs will also require operation at or above 160 °F. (Rheem, No. 1177 at p. 5)

In response to Rheem's request for a fixed set point temperature for high-temperature testing, DOE notes that not all water heaters with the capability to store water above 135 °F will necessarily have the capability to store water at 160 °F; hence, DOE is not adopting any changes to the set point requirements for the high-temperature test method. While the test may not be carried out at the exact temperature to which the water heater would be set in the field, it would be representative of the maximum temperature the water heater can sustain safely, which is important for consumer purchase decisions. UEF decreases with increased tank temperature; therefore, the water heater is expected to perform at least as well as a high-temperature rating evaluated at the highest tank temperature set point, all other environmental conditions the same. Should additional information become available regarding the set point temperatures of consumer electric resistance storage water heaters in the field, DOE may consider it in a future test procedure rulemaking.

c. Very Small and Large Electric Storage Water Heaters

In response to the July 2023 NOPR, some commenters stated that very small electric storage water heaters (*i.e.*, products with less than 20 gallons of rated storage volume) should not have to test to the high-temperature test method because these products are too small to reasonably substitute for larger heat pump water heaters, so it may be unlikely that these products are set to a high tank set point temperature.

Rheem suggested that the high-temperature test should be narrowly applied only to those electric storage water heaters which have potential to introduce a circumvention risk for heat pump water heater standards. In its comments, Rheem indicated that these products would be tabletop and electric storage water heaters with rated storage volumes greater than or equal to 20 gallons and less than or equal to 35 gallons. Rheem recommended that high-temperature testing should not apply to all other electric water heaters with storage volume. (Rheem, No. 1177 at p. 2) In its analysis, Rheem determined that a 19-gallon very small electric storage water heater would need to store water at 180 °F to achieve an FHR of approximately 51 gallons, which is much higher than is typically observed in consumer water heaters. On this basis, Rheem stated that very small electric storage water heaters cannot match the delivery capacities of 20–55 gallon electric storage water heaters, which would otherwise require heat pump technology. (Rheem, No. 1177 at pp. 2–3)

For electric resistance storage water heaters with rated storage volumes less than 20 gallons, AHRI recommended that high-temperature testing not be required because these units are unlikely to get into medium draw patterns at higher test temperatures. (AHRI, No. 1167 at p. 6)

A.O. Smith commented that, because small electric storage water heaters are the most likely to be operated at a higher temperature with a mixing valve to match the performance of larger water heaters, the high-temperature test method should be limited to small electric storage water heaters only. From its own testing of a 17-gallon very small electric storage water heater, A.O. Smith determined that increasing the set point from 125 °F to 150 °F resulted in a 43-percent increase in effective storage volume, but only a 4-percent increase in FHR, and thus A.O. Smith concluded that very small electric storage water heaters cannot match the performance of larger water heaters, even when operating at their highest set point temperatures. A.O. Smith recommended that DOE specify the high-temperature test only applies to 20–35 gallon products in order to maintain representativeness while reducing manufacturer testing burden. A.O. Smith commented that this would still "close the loophole" for heat pump water heater circumvention. (A.O. Smith, No. 1182 at pp. 6–7) Providing this information, A.O. Smith recommended that electric resistance storage water heaters of less than 20 gallons or greater than 55 gallons should be exempt from the high-temperature test method. (A.O. Smith, No. 1182 at p. 7)

To evaluate a potential exemption, DOE reviewed test data it had collected from very small electric storage water heaters in support of the proposed standards. These products, ranging in rated storage volume between 1.8 gallons and 19.9 gallons, all had delivery capacities in the very small or low draw patterns. Per its calculations, DOE also came to the same conclusion as commenters: no model would be capable of achieving an FHR high enough to place the water heater in the medium draw pattern at the highest tank temperature set point.

Based on DOE's data and information presented by commenters, DOE agrees that products with rated storage volumes of less than 20 gallons would not likely be set to higher temperatures to boost household delivery capacity as a substitute for a larger water heater. Therefore, DOE is exempting all very small electric storage water heaters from having to test to the high-temperature test method to demonstrate compliance with new UEF-based standards.

In addition to the previous suggestions provided by manufacturers, DOE received comments from NYSERDA and the CA IOUs suggesting that the high-temperature test method does not serve a purpose for larger electric resistance storage water heaters. NYSERDA stated that the high-temperature test method should not apply to larger-volume electric resistance storage water heaters that are already subject to heat pump-level standards. (NYSERDA, No. 1192 at p. 6) NYSERDA stated that exempting electric storage water heaters larger than 55 gallons of rated storage volume from the high-temperature test method (or potentially capping the effective storage volume) would reduce test burden and allow manufacturers to maintain the status quo for larger electric resistance storage water heaters. (NYSERDA, No. 1192 at p. 6) The CA IOUs suggested that DOE amend the calculations for effective storage volume such that products with rated storage volumes less than or equal to 120 gallons would be capped at an effective storage volume of 120 gallons. (CA IOUs, No. 1175 at pp. 3–4)

DOE agrees with NYSERDA and the CA IOUs that for products above a certain volume threshold, it is unlikely that testing according to the high-temperature method would provide more representative ratings. Specifically, the currently applicable standards for electric storage water heaters greater than 55 gallons of rated storage volume and less than or equal to 120 gallons of rated storage volume correspond to products with heat pump technology, such that all of these products on the market today are heat pump water heaters. (See 10 CFR 430.32(d)). Heat pump water heaters, discussed further in section V.D.1.d, would already be exempt from the high-temperature test method, as it is unlikely to be more representative for these products. Therefore, it is logical to exempt products that are 55–120 gallons of rated storage volume from the high-temperature test method, as this would be synonymous with the heat pump water heater exemption. Next, while DOE has not observed consumer electric storage water heaters on the market beyond 120 gallons of rated storage volume, it is unlikely that such very large products would rely on high-temperature operation to provide consumers with additional capacity: these products already contain rated storage volumes that are greater than those of products that have to comply with heat pump-level standards, such that the elevated temperature is not necessary to provide as much capacity as a heat pump water heater. Because of this, DOE has concluded that it is reasonable to exempt any electric storage water heater greater than 55 gallons of rated storage volume from the high-temperature test method.

This exemption for large electric storage water heaters additionally prevents potential backsliding from the standards of 55–120 gallon products, a concern brought up by multiple stakeholders and discussed in section IV.A.1.e, because the rated storage volume and effective storage volume would thus be equal for any model greater than 55 gallons. An electric storage water heater between 55 and 120 gallons of rated storage volume would be required to demonstrate compliance with standards in accordance with the normal temperature test method, meaning that it cannot use the high temperature test method to increase its effective storage volume beyond 120 gallons and become subject to less-stringent standards.

d. Optional Representations for Heat Pump Water Heaters

In the July 2023 NOPR, DOE proposed that high-temperature testing would not apply to products that meet the definition of “heat pump-type” water heater at 10 CFR 430.2. 88 FR 49058, 49166.

CEC stated their appreciation of DOE's recognition for the significant non-efficiency grid benefit potential provided by maximizing the thermal storage of heat pump water heaters through the use of higher set point temperatures and thermostatic mixing valves. (CEC, No. 1173 at p. 12)

Rheem supported allowing optional high-temperature representations for certain heat pump water heaters because high-temperature operation might become more representative of heat pump water heater installations for three main reasons: (1) the increased need for demand-response water heaters that can perform advanced load-up and high-temperature energy storage, (2) the longer recovery time for heat pumps can be offset by storing water at a higher temperature to increase the amount of hot water immediately available, and (3) because a heat pump increases the size of the water heater, a comparable FHR can require elevated storage temperature. Rheem suggested that high-temperature operation for heat pump water heaters could cause even units with high UEF ratings to perform worse in the field. (Rheem, No. 1177 at pp. 2–4)

As noted in section V.D.1 of this document, if a water heater in its default mode of operation[200] has an internal tank temperature that significantly exceeds the delivery set point temperature, the calculation of effective storage volume captures this effect even without the high-temperature test method. (*See* section 6.3.1.1 of Appendix E.) The FHR test would be carried out in this default mode and capture the increased delivery capacity. The 24-hour simulated-use test would be carried out in this default mode and would capture the increased standby losses from the higher-temperature operation. Therefore, if

[200] Section 5.1.1 of appendix E outlines the determination of the operational mode for testing heat pump water heaters, which shall be the default mode unless otherwise specified.

any heat pump water heater is designed to boost the tank temperature and incorporate a mixing valve as part of its normal operation, the effective storage volume, FHR, and UEF values resulting from the appendix E test procedure as written would be representative of this type of operation in the field.

DOE did not receive any other comments requesting that the high-temperature test method be made optional for voluntary representations of heat pump water heaters; however, DOE understands there is potential need to demonstrate storage and delivery capacity for heat pump water heaters representative of high-temperature operation that is not the default mode. Heat pump water heaters, unlike traditional electric resistance storage water heaters, can offer more modes to control the way the compressor and backup elements behave as a natural outcome of having more than one way to heat the water, and increasing storage tank temperature could be one potential way to increase delivery capacity when the compressor operates alone (*i.e.*, offers a slower recovery speed). In the June 2023 TP Final Rule, DOE adopted optional metrics for voluntary representations of heat pump water heaters to demonstrate performance in a variety of different environmental conditions because this information, DOE surmised, would be relevant for consumer information, and manufacturers already tested products to these alternate conditions. 88 FR 40406, 40437-40438. Similarly, DOE has determined that optional high-temperature representations would be relevant for consumer information as the market transitions towards this technology.

First, as discussed earlier, certain consumers using certain water heater configurations may desire higher set point temperatures, in which case the high-temperature test method could provide representative performance results. Second, as indicated by Rheem, future heat pump water heater control strategies could use variation of the storage tank temperature to compensate for slower compressor recovery periods when backup elements are either absent or disabled. A.O. Smith commented that consumers may be led to "upsize" when transitioning to a heat pump water heater (*see* section 0 of this document for further discussion of this comment); however, as Rheem suggested, high-temperature performance data could enable consumers to purchase smaller, less expensive heat pump water heaters if the high-temperature performance data demonstrate equivalent performance to a larger product.

Unlike the mandatory requirement for electric resistance storage water heaters, the high-temperature test is optional for heat pump water heaters. This is because DOE expects the representativeness of this test method to depend on the designs of heat pump water heaters that emerge within the compliance period of this final rule. At this time, heat pump water heaters comprise a relatively small portion of the market; therefore, consumer preferences and usage are not yet as well understood (whereas, for electric resistance storage water heaters, several commenters indicated that the high-temperature test method would be representative of field applications). Should higher tank temperatures become more prevalent in field use as a result of a technology transition, DOE may revisit the implementation of the high-temperature test method in a future test procedure rulemaking.

e. Temporary Mode

Some electric resistance water heaters could offer high-temperature modes that allow for set points above the intended delivery temperature to boost delivery capacity, but only temporarily before automatically reverting to the normal temperature mode. This contrasts with several models that are currently available, which remain in the high-temperature setting until the consumer changes the mode or setting to deactivate the high-temperature mode. Temporary modes would be intended for occasional use in situations in which there is a short-term increased demand for hot water, while non-temporary modes would be more likely to be used long-term. In the June 2023 TP Final Rule, DOE discussed comments it received from stakeholders regarding water heaters with high-temperature modes. Specifically, stakeholders indicated that high-temperature modes are not intended to be the primary mode of operation and should not be used continuously, and that testing in these modes would not reflect their intended use. 88 FR 40406, 40449.

DOE understands that temporary high-temperature modes would be unlikely to be used long-term because they would automatically return the set point to a more typical temperature after a certain period of time has elapsed. Because these temporary modes cannot be used permanently, in the July 2023 NOPR DOE tentatively determined that units capable of storing water at a set point above 135 °F only through a temporary, consumer-initiated, high-temperature mode lasting no longer than 120 hours should not be subject to high-temperature testing. 88 FR 49058, 49165. DOE expects that such products would operate in non-high temperature modes for the majority of the time and, therefore, testing in the high-temperature mode would not be representative. Thus, DOE proposed to limit the high-temperature mode duration to 120 hours as a reasonable amount of time that demand may be temporarily higher than normal (such as when guests are visiting). Further, DOE expected that models with permanent high-temperature modes, whether shipped from the factory with that mode as the default mode or simply as a user-selectable mode, would be likely to be used continuously in the high-temperature mode. Therefore, DOE tentatively concluded it is representative to test such water heaters in the high-temperature modes and is proposing to require such testing. *Id.*

GEA commented that DOE's 120-hour limit without user intervention for extra demand is an appropriate approach for maintaining consumer utility and the energy-saving benefits of such features. (GEA, No. 1203 at pp. 1-2)

AHRI requested that DOE provide additional information on what meets the definition of a "consumer-initiated" high-temperature mode, which, if lasting less than 120 hours, would deem the product exempt from the high-temperature test method. AHRI also inquired as to the type of interaction by the user that is necessary to satisfy the requirement and whether the user can create a schedule. AHRI raised a concern that if products fail to meet the specific requirement for the temporary mode exemption, products tested to the high-temperature test method would not be able to comply with standards. (AHRI, No. 1167 at p. 4) BWC also asked for DOE to further clarify what a "permanent mode or setting" meant for the high-temperature test exemption. (BWC, No. 1164 at pp. 7–8)

Stanonik stated that the proposed addition of high-temperature testing provisions is confusing, and added that the provisions may be read to apply to most electric storage water heaters despite the fact that DOE explains the provisions are only meant to apply to a subset of them. Stanonik requested DOE clarify if the act of changing the thermostat on a consumer water heater would be considered an "external consumer intervention" that would then exclude the water heater from high-temperature testing. (Stanonik, No. 1197 at p. 1)

Rheem stated that it was generally supportive of the outlined exemptions from the high-temperature test, except for the temporary setting exemption. Although Rheem had suggested that DOE investigate temporary modes of operation in the test procedure rulemaking, Rheem indicated in its comments to the July 2023 NOPR that such an exemption would not be necessary if the test method were clarified and the temperature criterion were raised from 135 °F to 140 °F. (Rheem, No. 1177 at pp. 6–7)

In response to these requests from stakeholders, DOE is clarifying what would constitute consumer intervention for the purpose of the high-temperature test exemption. As discussed in section V.D.1.b, a high-temperature mode would be one in which the water heater can achieve a $T_{max,1}$ greater than 135 °F during the 24-hour simulated-use test. If the water heater is set to such a mode, and the only time when it can achieve a $T_{max,1}$ greater than 135 °F is in the period of time that lasts 120 hours or less after the mode or setting is engaged by the user, then this would constitute a temporary high-temperature mode. To be exempt from the high-temperature test method, such a temporary high-temperature mode can only be activated via user intervention with the water heater. Once the temporary period of high-temperature operation has elapsed, the water heater must return to a lower tank temperature that would result in a $T_{max,1}$ less than or equal to 135 °F. If the user wishes to extend the period beyond 120 hours, they must reactivate the mode manually.

The purpose of this exemption is to allow products to increase capacity when there are limited times of high demand. Therefore, the consumer would have to manually activate the mode (*e.g.*, pushing a physical or digital button) if the high-temperature mode is required. If, instead, a product adheres to a regular schedule of high-temperature operation, a product would operate in a manner that demonstrates a consistent need for additional capacity, and in such a case the high-temperature test method would be more representative of the average daily use cycle of the product. For this reason, a scheduled setting would not be exempt from the high-temperature test method. For the normal-temperature test to remain representative of the ratings of the product, the water heater must permanently return to a mode in which the $T_{max,1}$ will not exceed 135 °F at any time after the temporary high-temperature operation has elapsed, and the only way in which the water heater would return to an elevated temperature is if the consumer interacts with the product manually again.

In response to Stanonik's question, the act of manually changing the set point temperature to achieve a mode in which the water heater can attain a $T_{max,1}$ beyond 135 °F is generally addressed in section V.D.1.b of this document. If the consumer can set the water heater to permanently heat and store water beyond 135 °F, then the water heater is not exempt from the high-temperature test. As outlined in section V.D.1.g of this document, such a model would not pass the second criterion for exemption.

f. Demand-Response Water Heaters

In the July 2023 NOPR, DOE proposed to exempt from high-temperature testing any water heaters that can only heat and store water at temperatures above 135 °F in response to instructions received from a utility or third-party demand-response program. DOE reasoned that the additional energy consumption from high-temperature water storage in demand-response water heaters is compensated for by periods of water heater inactivity (*i.e.*, a curtailment period) and, thus, demand-response water heaters do not engage in high-temperature water storage in order to directly increase capacity over a representative average use cycle of 24 hours. 88 FR 49058, 49166.

AHRI stated that it appreciated the exemptions from the high-temperature test method, especially regarding demand-response water heaters; however, AHRI asserted the demand-response exemption was not clearly defined. AHRI requested DOE clarify the extent of this exemption for manufacturers. (AHRI, No. 1167 at p. 2) AHRI commented that setting an arbitrary maximum temperature for electric storage water heaters may create potential issues for consumers in jurisdictions with demand-response requirements. Specifically, AHRI stated that load-up events for demand-response water heaters allow products to store energy, and limiting the temperature of the water heater will limit its load-up capability. AHRI requested that DOE consider increasing the temperature criterion for the high-temperature test exemptions in order to accommodate this function of demand-response water heaters. (AHRI, No. 1167 at p. 3)

BWC expressed concerns with how DOE's high-temperature test method might impact demand-response electric resistance water heaters, suggesting that there could still be complications for these products even with the exemption from the high-temperature test method. BWC stated that the purpose of demand-response controls, as required in many states, is to heat the unit to a higher temperature during off-peak hours to store energy during times of peak electric grid demand, and that these controls can be activated by either the utility or the consumer themselves. BWC commented that water heaters would be incapable of storing water at or above 135 °F if the proposal were finalized, which would limit the load-shifting capabilities of demand-response water heaters. (BWC, No. 1164 at p. 8)

In response to commenters' concern about demand-response water heaters being limited to 135 °F, DOE is clarifying the meaning of its proposed exemption to the high-temperature test method. As noted previously, DOE proposed that electric storage water heaters capable of heating and storing water over 135 °F only in response to utility demand response signals would not be subject to high-temperature testing. This exemption was proposed so that water heaters intended for use in demand-response programs would not have to limit their temperature, provided that the ability to raise the temperature is initiated only as part of the water heater's use in a demand-response program. (This does not, however, preclude a demand-response water heater from also having a manual temporary high-heat mode as described in the previous section.)

In this final rule, DOE is adopting an exemption to the high-temperature test method that will allow demand-response programs to elevate the temperature of the water heater to any temperature that the unit is capable of achieving, so long as the unit can only achieve those temperatures as a result of the demand-response operation and not as a result of the user increasing the set point temperature. For example, a product with its maximum user-operable set point can store water at or below 135 °F during normal operation, but in response to utility signals requesting a load-up, the product can increase the temperature to 160 °F (as an example) would be exempt from the high-temperature test method because the user cannot set the water heater to continuously operate above

135 °F. Whereas continuous operation above 135 °F would increase the effective storage volume and FHR of the water heater, a load-up event that prompts the water heater to increase the temperature above this point does not. The load-up event only temporarily boosts the temperature so that the water heater can rely on stored energy throughout peak grid demand periods instead of relying on electricity from the grid; therefore, over the course of a representative average-use cycle (one day), the water heater does not provide extra capacity compared to when it is set to a lower temperature and allowed to recover the tank throughout the day.

Additionally, AHRI questioned whether grid-enabled water heaters are also exempt from the high-temperature testing method. (AHRI, No. 1167 at p. 3) BWC also requested clarification on whether the high-temperature test method would apply to grid-enabled water heaters, as this was not mentioned in either the June 2023 TP Final Rule or the July 2023 NOPR. (BWC, No. 1164 at pp. 8–9) Rheem argued that, because grid-enabled water heaters are intended for demand-response, they are not a direct replacement for heat pump water heaters to a great extent, and that the high-temperature test method need not apply to grid-enabled water heaters. (Rheem, No. 1177 at p. 3)

Grid-enabled water heaters, discussed in section IV.A.1.e, are defined as having rated storage volumes greater than 75 gallons (see 10 CFR 430.2). In section V.D.1.c of this final rule, DOE concluded that products with rated storage volumes greater than 55 gallons would be exempt from the high-temperature test method. As a result, all grid-enabled water heaters are exempt from the high-temperature test method. Grid-enabled water heaters are a specific subset of electric storage water heater products, which must be enrolled with a grid utility program and are designed for the purpose of demand-response control. As such, DOE expects that these products achieve higher storage temperatures as a result of utility signals and not as a result of a consumer's need for additional hot water. Therefore, DOE has concluded that it is representative for grid-enabled water heaters to test to a normal set point temperature and not the high-temperature test method.

g. Summary of the High-Temperature Test Method Applicability

As a result of the considerations discussed in the previous sections, DOE is establishing that the high-temperature test method must be conducted for all electric storage water heaters, except for those meeting the following exemptions.

The first exemption is for products that are not capable of heating the stored water beyond a $T_{max,1}$ temperature of 135 °F. If the product has a $T_{max,1}$ less than or equal to 135 °F when tested in the user-operable mode that results in its highest set point, the product is exempt. This temperature criterion allows the water heater to maintain its utility of providing hotter water for certain consumer needs without increasing the temperature so much that the water heater can be used as a direct substitute for a larger water heater that must comply with more stringent standards. Beyond this temperature, the high-temperature test method is more representative of the product's use in the field.

The second exemption is for heat pump water heaters. As discussed previously, heat pump water heaters are unlikely to be used to a significant extent at high temperatures. However, in the event that a heat pump water heater is designed for high-temperature operation, the heat pump water heaters are allowed to use the high-temperature test method optionally for voluntary representations, but normal set point operation (section 5.1.1 of appendix E) is the mode that must be used to demonstrate compliance with standards.

The third exemption is for demand-response water heaters, specifically those products which can only attain temperatures beyond 135 °F when requested to do so by a utility signal. If a product does not allow the consumer to operate it in a manner that would result in a $T_{max,1}$ beyond 135 °F but does allow the grid to increase the tank temperature above this point, it remains exempt from the high-temperature test method.

The fourth exemption is for water heaters that allow the user to raise the temperature beyond 135 °F, but only for a maximum of 120 hours before automatically resetting to a temperature setting that results in $T_{max,1}$ at or below 135 °F. This allows water heaters to provide flexible-capacity modes for times when consumers may experience increased occupancy in the residence and thus a greater demand for hot water. The water heater must return to a mode that would result in a $T_{max,1}$ less than or equal to 135 °F after the 120-hour period elapses unless the user activates the boost mode again.

The fifth exemption is for water heaters of in-size categories where high-temperature operation is not expected to be representative of the product's function over an average daily use cycle. Very small electric storage water heaters (those with rated storage volumes less than 20 gallons) and large electric storage water heaters (those with rated storage volumes greater than 55 gallons) are not expected to use higher temperatures to boost capacity in order to be direct substitutes for products which have significantly more stringent standards.

This final rule adopts these five exemptions for section 5.1.2 of appendix E and 10 CFR 429.17.

2. Circulating Water Heaters

a. Separate Storage Tank Requirements

In response to the December 2023 SNOPR, NYSERDA encouraged DOE to review the test procedure to ensure that defining circulating water heaters as storage-type water heaters is consistent with the test method developed for these products. (NYSERDA, No. 1406 at p. 2)

The test method for circulating water heaters, as established by the June 2023 TP Final Rule, requires these products to be connected to a separate storage tank to serve as the volume of hot water that the circulating water heater requires for its function. *See* section 4.10 of the appendix E test procedure. As such, when a circulating water heater is tested per the appendix E test method, the test method will account for the stored volume of hot water and the standby losses that occur from it. This is analogous to how other traditional storage-type water heaters are tested.

When considering the potential impact of the proposed standards for electric storage water heaters on the availability of products to pair with heat pump circulating water heaters, DOE tentatively decided in the July 2023 NOPR that it would be more representative to pair such a product with an electric resistance storage water heater, surmising that is unlikely for consumers to pair a circulating heat pump water heater with an integrated heat pump water heater because they would already receive the energy-saving benefits of the integrated heat pump water heater. 88 FR 49058, 49167. Thus, in the July 2023 NOPR, DOE proposed to amend the separate storage tank requirement for a heat pump circulating water heater to reflect an electric resistance storage water heater that would be compliant with the proposed standards. Specifically, this proposed requirement was to pair a heat pump circulating water heater with a 30 gallon ± 5 gallon electric resistance storage water heater in the low draw pattern. *Id.*

In response to the July 2023 NOPR, some commenters indicated that heat pump circulating water heaters would be paired with a variety of tank sizes, meaning it would be impractical to base a rating for these products on just one tank pairing. Additionally, some commenters recommended alternative separate storage tank requirements to those proposed, or requested clarification.

A.O. Smith noted that gas-fired circulating water heaters present on the market today are only used in commercial applications, and the UFHWST tank pairing for these products is not common in residential applications, as it would result in a more expensive installation compared to a gas-fired storage water heater. (A.O. Smith, No. 1182 at p. 13)

BWC stated that it does not believe heat pump circulating water heaters should be coupled with 30 gallon ± 5 gallons electric storage water heaters in the appendix E test method for these products because this would not be realistic or representative of most real-world installations, which will typically rely on much larger tanks due to the slower recovery rate of a heat pump. BWC added that heat pump circulating water heaters are designed to meet a variety of unique residential applications in the field, which include different tank sizes and setups to provide adequate hot water, each of which would produce different efficiency ratings when tested; if forced to test to just one tank size, BWC stated that it would be compelled to cite to consumers an efficiency rating that is likely inflated and inaccurate compared to what the consumer will see in practice. BWC added further that a UFHWST, like that which is used for other types of circulating water heaters, would be a more representative pairing for heat pump circulating water heaters. (BWC, No. 1164 at pp. 12–13) Rheem suggested that heat pump circulating water heaters be certified with an UFHWST similar to other types of circulating water heaters because heat pump circulating water heaters may be developed to not rely on the use of backup electric resistance elements in an electric storage water heater tank. (Rheem, No. 1177 at pp. 14–15)

In section IV.A.1.a, DOE discussed its decision to consider circulating water heaters as storage-type water heaters. Therefore, circulating electric heat pump water heaters would be classified as electric storage water heaters and subject to the applicable electric storage water heater standards. DOE does not intend to stifle innovation in or misinform consumers on the efficiency and performance characteristics of heat pump circulating water heaters, which could be used by consumers in lieu of traditional heat pump water heaters. In the test procedure rulemaking, DOE received an abundance of feedback indicating that these products are most likely to be paired with electric resistance storage water heaters, which was the basis for the proposed tank pairing in the July 2023 NOPR. Notwithstanding the recommendations from BWC and Rheem, there remains uncertainty regarding the sizes of UFHWSTs that could be paired with a heat pump circulating water heater should these products not be used with electric resistance storage water heaters. Products DOE has found on the market have demonstrated positive results from case studies while being paired up with nominal 40-gallon electric resistance storage water heaters,[201] so it is expected that the products available today would remain compatible with slightly smaller tanks as well. Therefore, in this final rule, DOE concludes that an electric resistance storage water heater that is 30 gallons ± 5 gallons and in the low draw pattern is still a representative pairing based on feedback received in the test procedure rulemaking.

In response to the December 2023 SNOPR, BWC commented that manufacturers will need to be able to test gas-fired circulating water heaters with a greater range of unfired hot water storage tank volumes than that which is specified in the June 2023 TP Final Rule. (BWC, No. 1413 at p. 2)

However, without consumer gas-fired circulating water heaters on the market, there is insufficient information (other than the feedback received during the test procedure rulemaking) to make a determination to amend the separate storage tank pairing for these products. The test method to pair gas-fired circulating water heaters with 80- to 120-gallon unfired hot water storage tanks was developed after careful consideration of numerous comments provided in that rulemaking. While finalizing the amendment as proposed, DOE will continue to assess the representativeness of the separate storage tank provisions in the appendix E test procedure and address these concerns in a future test procedure rulemaking if necessary.

[201] A case study published by Nyle Water Heating Systems demonstrates the use of a circulating heat pump water heater with a nominal 40-gallon electric storage water heater. See online at: *www.nyle.com/wp-content/uploads/2021/09/Case-Study-3.2.pdf* (Last accessed: Jan. 5, 2024).

Rheem stated its understanding that circulating water heaters would be tested with a manufacturer-specified storage tank, and that the storage tanks described in section 4.10 of appendix E would only be used if there was no manufacturer-specified storage tank. (Rheem, No. 1408 at p. 2) AHRI and A.O. Smith requested that DOE clarify whether a manufacturer would be able to make efficiency representations of circulating water heaters that are designed and specified (or shipped) for use with a storage tank that does not fall into the volume ranges outlined in the test procedure and enforcement provisions. (A.O. Smith, No. 1182 at p. 7; AHRI, No. 1167 at pp. 13–14)

The Department intends for the separate storage tank requirements in section 4.10 to apply to circulating water heaters, which are storage-type water heaters that are not sold with a tank. DOE understands that there may be some confusion based on the wording of section 1.19 of appendix E, which reads that a "water heater requiring a storage tank" means a water heater without a storage tank specified or supplied by the manufacturer that cannot meet the requirements of sections 2 and 5 of appendix E without the use of a storage water heater or unfired hot water storage tank. The current wording of section 1.19 in appendix E inadvertently conflates circulating water heaters with split-system water heaters—the distinctions between these two are discussed in section IV.A.1.f.i of this document. As such, DOE is making a minor amendment to section 1.19 of appendix E to resolve industry confusion around these distinctions after determining that it is clearer to define a "water heater requiring a storage tank" as a water heater without a storage tank supplied by the manufacturer that cannot meet the requirements of sections 2 and 5 of appendix E without the use of a storage water heater or unfired hot water storage tank. This edit removes the possibility that a water heater could have a manufacturer-specified tank pairing but would have to be tested with a different separate storage tank. Simultaneously DOE is clarifying in section 4.10 of appendix E that those setup provisions apply to water heaters requiring a storage tank—a term that is essentially synonymous with “circulating water heater.”

In response to the questions from AHRI and A.O. Smith, representations of circulating water heaters must be made in accordance with the separate storage tank requirements in the appendix E test procedure. The compliance of the circulating water heater with the appropriate storage water heater standards would be determined based on the storage volume of the tank selected, which in turn determines the effective storage volume of the circulating water heater. For all types of circulating water heaters, should a manufacturer desire to report its performance to multiple tank sizes, each tank size would constitute a separate basic model.

Reporting requirements are not being established in this rulemaking addressing energy conservation standards for consumer water heaters, however, and DOE will propose these requirements in a separate rulemaking.

b. Product-Specific Enforcement Provisions

In the July 2023 NOPR, DOE proposed a series of steps it would take to ensure that the UFHWST used in assessment testing is as close as possible to the model that was used to determine the circulating water heater's rating. As stated earlier, reporting requirements are not being addressed in this rulemaking, but will be considered separately. 88 FR 49058, 49167. The intent of DOE's proposal was to create a procedure that would default to using the same tank that the circulating water heater manufacturer used, but in the extenuating circumstance wherein that tank is unavailable to DOE, the model could still be tested.

A.O. Smith recommended that DOE bolster the enforcement provisions and definitions outlining what would constitute a circulating water heater to prevent the emergence of electric resistance circulating water heater configurations. (A.O. Smith, No. 1182 at pp. 12–13) A.O. Smith also asked DOE to clarify certification requirements for circulating water heaters. (A.O. Smith, No. 1182 at p. 7) BWC stated that several provisions leave open the possibility that DOE could conduct enforcement testing with a significantly different UFHWST, including the possibility of testing with a different manufacturer's tank. BWC added that this could lead to unfair results, and that instead DOE should allow manufacturers to provide DOE with the UFHWST that is to be paired with the circulating water heater. (BWC, No. 1164 at pp. 13–14) BWC requested that DOE reconsider its proposed product-specific enforcement provisions for circulating water heaters, which include the steps DOE would take to test with an UFHWST as similar as possible to the one used by the manufacturer to rate the circulating water heater, so that the manufacturer could provide the UFHWST to DOE for testing. (BWC, No. 1164 at pp. 13–14) Rheem requested that DOE clarify whether the effective storage volume is a more appropriate metric to use than rated storage volume in the enforcement provisions proposed. Rheem supported the enforcement provisions proposed for testing these products but suggested that DOE test at the lowest storage volume available within the 80–120 gallon range for UFHWSTs. (Rheem, No. 1177 at pp. 14–15)

In response to the request from BWC, DOE does not directly source the tank from manufacturers as it would limit the ability for independent assessment testing given that manufacturers are not always notified when assessment testing occurs.

In response to Rheem's question about rewriting provisions to use the effective storage volume metric, it is unclear where a change would apply, because the provisions outline the steps with regard to the characteristics of the UFHWST, and UFHWSTs have a certified storage volume rather than an effective storage volume.

As such, DOE is finalizing the product-specific enforcement provisions for circulating water heaters as proposed in the July 2023 NOPR. DOE may re-evaluate the product-specific enforcement provisions for these products in a separate rulemaking.

3. Water Heaters Less Than 2 Gallons

The July 2023 NOPR proposed to establish new UEF-based standards for electric and gas storage-type water heaters with less than 20 gallons of effective storage volume. In its market assessment DOE has found models of consumer electric storage-type water heaters which are less than 2 gallons in nominal volume. In order for manufacturers to determine compliance for these products, the test procedure must include provisions for calculating the rated storage volume and effective storage volume.

The current method to determine storage tank volume in the appendix E test procedure, as amended by the June 2023 TP Final Rule, states:

"For water heaters with a rated storage volume greater than or equal to 2 gallons and for separate storage tanks used for testing circulating water heaters, determine the storage capacity, of the water heater or separate storage tank under test, in gallons (liters), by subtracting the tare weight from the gross weight of the storage tank when completely filled with water at the supply water temperature specified in section 2.3."

(See section 5.2.1 of the amended appendix E test procedure); 88 FR 40406, 40478.

However, this method does not explicitly cover storage-type water heaters less than 2 gallons which will be covered under the proposed new UEF-based standards. Therefore, in the July 2023 NOPR, DOE proposed to amend section 5.2.1 such that it is applicable to water heaters of all volumes and not restricted to only products greater than or equal to 2 gallons.

No comments were received in response to this proposal. Therefore, DOE is adopting this update to appendix E as proposed in the July 2023 NOPR.

4. Other Topics

In the June 2023 TP Final Rule, DOE adopted optional provisions at section 2.8 of appendix E to allow manufacturers to make voluntary representations of heat pump water heater performance in a variety of alternative conditions that could be useful for consumers installing these products in different locations. These alternative conditions would not be used to determine compliance with the UEF standards at 10 CFR 430.32(d) but were provided to permit representations at the NEEA Advanced Water Heating Specification version 8.0 conditions.[202] 88 FR 40406, 40476.

Rheem requested that DOE address certification and enforcement provisions for heat pump water heaters being tested to the optional test conditions in section 2.8 of appendix E. (Rheem, No. 1177 at p. 7)

DOE reiterates that optional conditions cannot be used to demonstrate compliance with standards. DOE is not adopting certification and enforcement provisions for optional test conditions in this final rule but may consider this in a future rulemaking addressing these topics.

VI. Procedural Issues and Regulatory Review

A. Review Under Executive Orders 12866, 13563, and 14094

Executive Order ("E.O.") 12866, "Regulatory Planning and Review," as supplemented and reaffirmed by E.O. 13563, "Improving Regulation and Regulatory Review," 76 FR 3821 (Jan. 21, 2011) and amended by E.O. 14094, "Modernizing Regulatory Review," 88 FR 21879 (April 11, 2023), requires agencies, to the extent permitted by law, to (1) propose or adopt a regulation only upon a reasoned determination that its benefits justify its costs (recognizing that some benefits and costs are difficult to quantify); (2) tailor regulations to impose the least burden on society, consistent with obtaining regulatory objectives, taking into account, among other things,

[202] Representations of rated values for consumer water heaters must be made in accordance with the provisions of the Federal test procedure, appendix E. (42 U.S.C. 6293(c)).

and to the extent practicable, the costs of cumulative regulations; (3) select, in choosing among alternative regulatory approaches, those approaches that maximize net benefits (including potential economic, environmental, public health and safety, and other advantages; distributive impacts; and equity); (4) to the extent feasible, specify performance objectives, rather than specifying the behavior or manner of compliance that regulated entities must adopt; and (5) identify and assess available alternatives to direct regulation, including providing economic incentives to encourage the desired behavior, such as user fees or marketable permits, or providing information upon which choices can be made by the public. DOE emphasizes as well that E.O. 13563 requires agencies to use the best available techniques to quantify anticipated present and future benefits and costs as accurately as possible. In its guidance, the Office of Information and Regulatory Affairs ("OIRA") in the Office of Management and Budget ("OMB") has emphasized that such techniques may include identifying changing future compliance costs that might result from technological innovation or anticipated behavioral changes. For the reasons stated in the preamble, this final regulatory action is consistent with these principles.

Section 6(a) of E.O. 12866 also requires agencies to submit "significant regulatory actions" to OIRA for review. OIRA has determined that this final regulatory action constitutes a "significant regulatory action" within the scope of section 3(f)(1) of E.O. 12866. Accordingly, pursuant to section 6(a)(3)(C) of E.O. 12866, DOE has provided to OIRA an assessment, including the underlying analysis, of benefits and costs anticipated from the final regulatory action, together with, to the extent feasible, a quantification of those costs; and an assessment, including the underlying analysis, of costs and benefits of potentially effective and reasonably feasible alternatives to the planned regulation, and an explanation why the planned regulatory action is preferable to the identified potential alternatives. These assessments are summarized in this preamble, and further detail can be found in the technical support document for this rulemaking.

B. Review Under the Regulatory Flexibility Act

The Regulatory Flexibility Act (5 U.S.C. 601 *et seq*.) requires preparation of an initial regulatory flexibility analysis ("IRFA") and a final regulatory flexibility analysis ("FRFA") for any rule that by law must be proposed for public comment, unless the agency certifies that the rule, if promulgated, will not have a significant economic impact on a substantial number of small entities. As required by E.O. 13272, "Proper Consideration of Small Entities in Agency Rulemaking," 67 FR 53461 (Aug. 16, 2002), DOE published procedures and policies on February 19, 2003, to ensure that the potential impacts of its rules on small entities are properly considered during the rulemaking process. 68 FR 7990. DOE has made its procedures and policies available on the Office of the General Counsel's website (*www.energy.gov/gc/office-general-counsel*). DOE has prepared the following FRFA for the products that are the subject of this rulemaking.

For manufacturers of consumer water heaters, the SBA has set a size threshold, which defines those entities classified as "small businesses" for the purposes of the statute. DOE used the SBA's small business size standards to determine whether any small entities would be subject to the requirements of the rule. (See 13 CFR part 121.) The size standards are listed by North American Industry Classification System ("NAICS") code and industry description and are available at *www.sba.gov/document/support-table-size-standards*. Manufacturing of consumer water heaters is classified under NAICS 335220, "Major Household Appliance Manufacturing." The SBA sets a threshold of 1,500 employees or fewer for an entity to be considered as a small business for this category.

1. Need for, and Objectives of, Rule

EPCA prescribed energy conservation standards for consumer water heaters (42 U.S.C. 6295(e)(1)) and directed DOE to conduct two cycles of rulemakings[203] to determine whether to amend these standards. (42 U.S.C. 6295(e)(4)) EPCA further provides that, not later than 6 years after the issuance of any final rule establishing or amending a standard, DOE must publish either a notice of determination that standards for the product do not need to be amended, or a NOPR including new proposed energy conservation standards (proceeding to a final rule, as appropriate). (42 U.S.C. 6295(m)(1))

2. Significant Issues Raised by Public Comments in Response to the IRFA

In response to the July 2023 NOPR, the Gas Association Commenters submitted comments noting that DOE identified only two small businesses, neither of which produce gas-fired water heaters. As a result, the Gas Association Commenters stated that DOE has no data on small businesses that produce gas-fired water heaters relative to redesign costs, product availability, or whether the proposed efficiency levels could cause small businesses to exit the market. (Gas Association Commenters No. 1181, pp. 38–39)

[203] DOE completed the first of these rulemaking cycles on January 17, 2001, by publishing in the *Federal Register* a final rule amending the energy conservation standards for consumer water heaters. 66 FR 4474. Subsequently, DOE completed the second rulemaking cycle to amend the standards for consumer water heaters by publishing a final rule in the *Federal Register* on April 16, 2010. 75 FR 20112.

NPGA, APGA, AGA, and Rinnai stated that as the two small businesses DOE identified in the July 2023 NOPR analysis do not produce gas-fired water heaters, DOE cannot know what the effect on small businesses that manufacture gas-fired water heaters could be as DOE has no data on their redesign costs, product availability, or whether the standards proposed in the July 2023 NOPR would force these manufacturers to leave the market. Therefore, NPGA, APGA, AGA, and Rinnai asserted that the July 2023 NOPR fails to comply with Executive Order 13272, "Proper Consideration of Small Entities in Agency Rulemaking," and must be addressed. (NPGA, APGA, AGA, and Rinnai, No. 441 at p. 5)

For the IRFA conducted in support of the July 2023 NOPR, DOE identified one small domestic original equipment manufacturer ("OEM") of oil-fired storage water heaters and one small domestic OEM of electric storage water heaters. For this FRFA, DOE refreshed its product database to include up-to-date information on the consumer water heater models marketed for the United States. Based on its comprehensive review of the market, DOE identified an additional small, domestic OEM of electric storage water heaters. Therefore, DOE maintains its finding from the IRFA that there are no small, domestic OEMs that manufacture gas-fired water heaters. As such, DOE does not expect that the standards adopted in this final rule would directly impact small businesses that manufacture gas-fired water heaters.

BWC expressed concern about the extensive resources such an undertaking would divert from ongoing projects, as well as its potentially more severe impacts on smaller manufacturers, including component suppliers. (BWC, No. 1164 at p. 15) ASA stated that manufacturers and distributors, including small businesses, would be negatively affected by increased costs for both units and installation and that consumer choice would be restricted. ASA requested that DOE update data used to develop these standards. (ASA, No. 1160 at p. 1)

DOE agrees that the impacts small manufacturers experience may differ compared to larger, more diversified manufacturers. DOE conducts a regulatory flexibility analysis to understand and assess the potential impacts to small domestic OEMs that produce consumer water heaters for the U.S. market in accordance with the procedures and policies published on February 19, 2003. 68 FR 7990. *See* section 0 of this document for a discussion of potential impacts of amended standards on the three small businesses with U.S. manufacturing facilities identified.

3. Description and Estimated Number of Small Entities Affected

For this FRFA, DOE refreshed its product database to use up-to-date information on the models available on the U.S. market and estimate the number of companies that could be small business manufacturers of products covered by this rulemaking. DOE's research involved reviewing its CCD,[204] California Energy Commission's Modernized Appliance Efficiency Database System ("MAEDbS"),[205] EPA's Energy Star Product Finder dataset,[206] AHRI's Directory of Certified Product Performance,[207] individual

[204]U.S. Department of Energy's Compliance Certification Database is available at *regulations.doe.gov/certification-data* (last accessed May 16, 2023).
[205] California Energy Commission's Modernized Appliance Efficiency Database System is available at *cacertappliances.energy.ca.gov/Pages/Search/AdvancedSearch.aspx* (last accessed November 13, 2023).
[206] U.S. Environmental Protection Agency's ENERY STAR Product Finder dataset is available at *www.energystar.gov/productfinder/* (last accessed November 13, 2023).
[207]AHRI's Directory of Certified Product Performance is available at *www.ahridirectory.org/Search/SearchHome?ReturnUrl=%2f* (last accessed May 16, 2023).

company websites, and market research tools (*e.g.*, reports from D&B Hoovers[208]) to create a list of companies that manufacture, produce, import, or assemble the products covered by this rulemaking. DOE also asked stakeholders and industry representatives if they were aware of any other small manufacturers during manufacturer interviews.

DOE identified 22 OEMs of electric instantaneous, electric storage, gas-fired instantaneous, gas-fired storage, or oil-fired storage water heaters sold in the United States as part of its July 2023 NOPR analysis. In preparation for the final rule, DOE conducted additional research to ensure an up-to-date data on the consumer water heater market. After a further comprehensive review of the model listings, DOE concluded that three of the manufacturers previously identified do not manufacture consumer water heaters in-house (*i.e.*, they do not own and operate manufacturing facilities that produce consumer water heaters). However, DOE determined there are three additional manufacturers not previously identified that manufacture consumer water heaters in-house. DOE also revised its OEM count estimate to exclude manufacturers of gas-fired instantaneous water heaters since this final rule does not cover gas-fired instantaneous water heaters. Therefore, excluding manufacturers that only offer gas-fired instantaneous water heaters, DOE identified 16 OEMs of consumer water heaters covered by this final rule. Of these 16 OEMs, DOE identified three small, domestic manufacturers affected by amended standards for gas-fired storage water heater, oil-fired storage water heater, or electric storage water heater products. The first small business is an OEM of oil-fired

[208] The D&B Hoovers subscription login is available at *app.dnbhoovers.com.*

storage water heaters. The other two small businesses are OEMs of electric storage water heaters.

4. Description of Reporting, Recordkeeping, and Other Compliance Requirements

The first small business is an OEM that certifies three models of oil-fired storage water heaters. One of the three models would meet the standard. Given the small and shrinking market for oil-fired storage water heaters, DOE does not expect the small manufacturer would redesign non-compliant models. Rather, the company would likely reduce its range of model offerings. DOE requested input on the potential impacts of standards on this manufacturer in the July 2023 NOPR, but did not receive any feedback. DOE, therefore, maintains its assumption from the IRFA that this manufacturer would not incur significant conversion costs as a result of this rulemaking.

The second small business is an OEM that certifies eleven models of electric storage water heaters. The company offers two small electric storage water heaters, six electric storage water heaters with an effective storage volume greater than or equal to 20 gallons and less than or equal to 55 gallons, and three electric storage water heaters with effective storage volumes above 55 gallons. At the adopted level (TSL 2), DOE does not expect the two small electric water heater models would require notable redesign as standard levels would remain at the baseline efficiency level (*i.e.*, EL 0) for small electric water heaters. None of the six electric storage water heaters (between 20 and 55 gallons, excluding small electric storage water heaters) would meet the amended standard. However, one of the six electric storage water heaters (between 20 and 55 gallons, excluding small electric storage water heaters) is a heat pump model that would likely not require significant redesign to meet the amended standards. DOE expects the company would expand its heat pump offering rather than redesign the electric resistance products that do not meet the amended standard. The company offers three electric storage water heaters with effective storage volumes above 55 gallons. All three of these are heat pumps that do not meet the amended standard. After reviewing the three electric storage water heaters with effective storage volumes above 55 gallons, DOE believes the three models could be updated to meet the amended standard. In total, the company would need to redesign up to nine models.

DOE assumed the company would need to invest the equivalent of one year of its R&D resources to update its product lines to meet amended standards. Therefore, to derive this company's estimated product conversion costs, DOE scaled the annual industry R&D expenditures for electric storage water heaters in the GRIM by the company's estimated market share. DOE does not anticipate significant capital conversion costs, as the company offers a broad line of heat pump electric storage water heaters today. DOE estimates total conversion costs to be $250,000 for this small manufacturer. Based on market research tools, DOE estimated the company's annual revenue to be approximately $50 million. Taking into account the 5-year conversion period, DOE expects conversion costs to be less than 1 percent of conversion period revenue.[209]

The third small business is an OEM that produces two models of circulating water heaters, which are not currently required to comply with a UEF standard. DOE expects

[209] DOE calculated total conversion costs as a percent of revenue over the 5-year conversion period using the following calculation: ($0.25 million)/(5 years x $50 million).

that both of these models would qualify as small electric storage water heaters, and thus would likely be subject to new and amended UEF standards. At the adopted level (TSL 2), the standard required for small electric storage water heaters would remain at the baseline efficiency level. DOE notes that both of the models identified utilize heat pump technology. Therefore, DOE assumes these models would not need to be redesigned to comply with new and amended UEF standards. However, this small manufacturer would need to certify these models at the time of compliance with new and amended standards, incurring testing costs of $3,000 per basic model. 88 FR 40406, 40467. Based on market research tools, DOE estimated the company's annual revenue to be approximately $7.7 million. Taking into account the 5-year conversion period, DOE expects conversion costs to be less than 1 percent of conversion period revenue.[210]

5. Significant Alternatives Considered and Steps Taken to Minimize Significant Economic Impacts on Small Entities

The discussion in the previous section analyzes impacts on small businesses that would result from adopted standards, represented by TSL 2. In reviewing alternatives to the adopted standards, DOE examined energy conservation standards set at lower efficiency levels. While TSL 1 would reduce the impacts on small business manufacturers, it would come at the expense of a reduction in energy savings. TSL 1 achieves 98-percent lower energy savings compared to the energy savings at TSL 2.

[210] DOE calculated total conversion costs as a percent of revenue over the 5-year conversion period using the following calculation: ($6,000)/(5 years x $7,700,000).

Based on the presented discussion, establishing standards at TSL 2 balances the benefits of the energy savings with the potential burdens placed on consumer water heater manufacturers, including small business manufacturers. Accordingly, DOE does not adopt one of the other TSLs considered in the analysis, nor the other policy alternatives examined as part of the regulatory impact analysis and included in chapter 17 of the final rule TSD.

Additional compliance flexibilities may be available through other means. EPCA provides that a manufacturer whose annual gross revenue from all its operations does not exceed $8 million may apply for an exemption from all or part of an energy conservation standard for a period not longer than 24 months after the effective date of a final rule establishing the standard. (42 U.S.C. 6295(t)) Additionally, manufacturers subject to DOE's energy efficiency standards may apply to DOE's Office of Hearings and Appeals for exception relief under certain circumstances. Manufacturers should refer to 10 CFR part 430, subpart E, and 10 CFR part 1003 for additional details.

C. Review Under the Paperwork Reduction Act

Manufacturers of consumer water heaters must certify to DOE that their products comply with any applicable energy conservation standards. In certifying compliance, manufacturers must test their products according to the DOE test procedures for consumer water heaters, including any amendments adopted for those test procedures. DOE has established regulations for the certification and recordkeeping requirements for all covered consumer products and commercial equipment, including consumer water heaters. (*See* generally 10 CFR part 429). The collection-of-information requirement for the certification and recordkeeping is subject to review and approval by OMB under the Paperwork Reduction Act ("PRA"). This requirement has been approved by OMB under OMB control number 1910-1400. Public reporting burden for the certification is estimated to average 35 hours per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information.

Notwithstanding any other provision of the law, no person is required to respond to, nor shall any person be subject to a penalty for failure to comply with, a collection of information subject to the requirements of the PRA, unless that collection of information displays a currently valid OMB Control Number.

D. Review Under the National Environmental Policy Act of 1969

Pursuant to the National Environmental Policy Act of 1969 ("NEPA"), DOE has analyzed this proposed action rule in accordance with NEPA and DOE's NEPA implementing regulations (10 CFR part 1021). DOE has determined that this rule qualifies for categorical exclusion under 10 CFR part 1021, subpart D, appendix B5.1 because it is a rulemaking that establishes energy conservation standards for consumer products or industrial equipment, none of the exceptions identified in B5.1(b) apply, no extraordinary circumstances exist that require further environmental analysis, and it meets the requirements for application of a categorical exclusion. *See* 10 CFR 1021.410. Therefore, DOE has determined that promulgation of this rule is not a major Federal action significantly affecting the quality of the human environment within the meaning of

NEPA and does not require an environmental assessment or an environmental impact statement.

E. Review Under Executive Order 13132

E.O. 13132, "Federalism," 64 FR 43255 (Aug. 10, 1999), imposes certain requirements on Federal agencies formulating and implementing policies or regulations that preempt State law or that have Federalism implications. The Executive order requires agencies to examine the constitutional and statutory authority supporting any action that would limit the policymaking discretion of the States and to carefully assess the necessity for such actions. The Executive order also requires agencies to have an accountable process to ensure meaningful and timely input by State and local officials in the development of regulatory policies that have Federalism implications. On March 14, 2000, DOE published a statement of policy describing the intergovernmental consultation process it will follow in the development of such regulations. 65 FR 13735.

In the July 2023 NOPR, DOE tentatively determined that the proposed rule would not have a substantial direct effect on the States, on the relationship between the national government and the States, or on the distribution of power and responsibilities among the various levels of government. 88 FR 49058, 49170. Furthermore, DOE stated that EPCA governs and prescribes Federal preemption of State regulations as to energy conservation for the products that are the subject of the proposed rule and that States can petition DOE for exemption from such preemption to the extent, and based on criteria, set forth in EPCA. *Id.* (citing 42 U.S.C. 6297). Accordingly, DOE concluded that no further action was required by E.O. 13132.

As initially discussed in section III.A.2 of this document, the Attorney General of TN commented that the proposed standards have significant federalism implications within the meaning of Executive Order 13132 because: (1) DOE's standards have a preemptive effect on States' procurement standards; and (2) States own and purchase water heaters and therefore the proposed standards' effect on water heater costs directly affect States as purchasers. (Attorney General of TN, No. 1149 at pp. 2–3)

DOE reiterates that this final rule does not have significant federalism implications. DOE has examined this rule and has determined that it would not have a substantial direct effect on the States, on the relationship between the national government and the States, or on the distribution of power and responsibilities among the various levels of government. EPCA governs and prescribes Federal preemption of State regulations as to energy conservation for the products that are the subject of this final rule. Additionally, Federal energy efficiency requirements for covered products established under EPCA, including consumer water heaters, generally supersede State laws and regulations concerning energy conservation testing, labeling, and standards. (42 U.S.C. 6297(a)-(c)) States can petition DOE for exemption from such preemption to the extent, and based on criteria, set forth in EPCA. (42 U.S.C. 6297) Therefore, no further action is required by Executive Order 13132.

Even if DOE were to find otherwise, with regards to the Attorney General of TN's arguments regarding E.O. 13132, DOE notes that the Attorney General of TN does not provide any examples of a state procurement rule that conflicts with the standards adopted in this rulemaking and DOE is not aware of any such conflicts, nor has the Attorney General of TN provided any examples of States owning and purchasing a substantial number of consumer water heaters. While it is possible that a State may have to revise its procurement standards to reflect the new standards, States can petition DOE for exemption from such preemption to the extent, and based on criteria, set forth in EPCA. Absent such information, DOE concludes that no further action would be required by E.O. 13132 even if the Executive order were applicable here. Moreover, assuming the hypothetical preemption alleged by the Attorney General of TN were to present itself, DOE notes that, like all interested parties, states were presented with an opportunity to engage in the rulemaking process early in the development of the proposed rule. Prior to publishing the proposed rulemaking, on May 21, 2020, DOE published and sought public comment on an RFI to collect data and information to help DOE determine whether any new or amended standards for consumer water heaters would result in a significant amount of additional energy savings and whether those standards would be technologically feasible and economically justified. 85 FR 30853. DOE then published a notice of public meeting and availability of the preliminary TSD on March 1, 2022, and sought public comment again. 87 FR 11327. DOE then held a public meeting on April 12, 2022, to discuss and receive comments on the preliminary TSD, which was open to the public, including state agencies. As such, states were provided the opportunity for meaningful and substantial input as envisioned by the Executive order.

F. Review Under Executive Order 12988

With respect to the review of existing regulations and the promulgation of new regulations, section 3(a) of E.O. 12988, “Civil Justice Reform,” imposes on Federal agencies the general duty to adhere to the following requirements: (1) eliminate drafting errors and ambiguity, (2) write regulations to minimize litigation, (3) provide a clear legal standard for affected conduct rather than a general standard, and (4) promote simplification and burden reduction. 61 FR 4729 (Feb. 7, 1996). Regarding the review required by section 3(a), section 3(b) of E.O. 12988 specifically requires that Executive agencies make every reasonable effort to ensure that the regulation (1) clearly specifies the preemptive effect, if any, (2) clearly specifies any effect on existing Federal law or regulation, (3) provides a clear legal standard for affected conduct while promoting simplification and burden reduction, (4) specifies the retroactive effect, if any, (5) adequately defines key terms, and (6) addresses other important issues affecting clarity and general draftsmanship under any guidelines issued by the Attorney General. Section 3(c) of E.O. 12988 requires Executive agencies to review regulations in light of applicable standards in section 3(a) and section 3(b) to determine whether they are met or it is unreasonable to meet one or more of them. DOE has completed the required review and determined that, to the extent permitted by law, this final rule meets the relevant standards of E.O. 12988.

G. Review Under the Unfunded Mandates Reform Act of 1995

Title II of the Unfunded Mandates Reform Act of 1995 ("UMRA") requires each Federal agency to assess the effects of Federal regulatory actions on State, local, and Tribal governments and the private sector. Pub. L. 104-4, sec. 201 (codified at 2 U.S.C. 1531). For a regulatory action likely to result in a rule that may cause the expenditure by State, local, and Tribal governments, in the aggregate, or by the private sector of $100 million or more in any one year (adjusted annually for inflation), section 202 of UMRA requires a Federal agency to publish a written statement that estimates the resulting costs, benefits, and other effects on the national economy. (2 U.S.C. 1532(a),(b)) The UMRA also requires a Federal agency to develop an effective process to permit timely input by elected officers of State, local, and Tribal governments on a "significant intergovernmental mandate," and requires an agency plan for giving notice and opportunity for timely input to potentially affected small governments before establishing any requirements that might significantly or uniquely affect them. On March 18, 1997, DOE published a statement of policy on its process for intergovernmental consultation under UMRA. 62 FR 12820. DOE's policy statement is also available at *energy.gov/sites/prod/files/gcprod/documents/umra_97.pdf.*

DOE has concluded that this final rule may require expenditures of $100 million or more in any one year by the private sector. Such expenditures may include (1) investment in research and development and in capital expenditures by consumer water heater manufacturers in the years between the final rule and the compliance date for the new standards, and (2) incremental additional expenditures by consumers to purchase higher-efficiency consumer water heaters, starting at the compliance date for the applicable standard.

Section 202 of UMRA authorizes a Federal agency to respond to the content requirements of UMRA in any other statement or analysis that accompanies the final rule. (2 U.S.C. 1532(c)) The content requirements of section 202(b) of UMRA relevant to a private sector mandate substantially overlap the economic analysis requirements that apply under section 325(o) of EPCA and Executive Order 12866. The **SUPPLEMENTARY INFORMATION** section of this document and the TSD for this final rule respond to those requirements.

Under section 205 of UMRA, DOE is obligated to identify and consider a reasonable number of regulatory alternatives before promulgating a rule for which a written statement under section 202 is required. (2 U.S.C. 1535(a)) DOE is required to select from those alternatives the most cost-effective and least burdensome alternative that achieves the objectives of the rule unless DOE publishes an explanation for doing otherwise, or the selection of such an alternative is inconsistent with law. As required by 42 U.S.C. 6295(m), this final rule establishes new and amended energy conservation standards for consumer water heaters that are designed to achieve the maximum improvement in energy efficiency that DOE has determined to be both technologically feasible and economically justified, as required by 6295(o)(2)(A) and 6295(o)(3)(B). A full discussion of the alternatives considered by DOE is presented in chapter 17 of the TSD for this final rule.

H. Review Under the Treasury and General Government Appropriations Act, 1999

Section 654 of the Treasury and General Government Appropriations Act, 1999 (Pub. L. No. 105–277) requires Federal agencies to issue a Family Policymaking Assessment for any proposed rule or policy that may affect family well-being. Although this final rule would not have any impact on the autonomy or integrity of the family as an institution as defined, this rule could impact a family's well-being. When developing a Family Policymaking Assessment, agencies must assess whether: (1) the action strengthens or erodes the stability or safety of the family and, particularly, the marital commitment; (2) the action strengthens or erodes the authority and rights of parents in the education, nurture, and supervision of their children; (3) the action helps the family perform its functions, or substitutes governmental activity for the function; (4) the action increases or decreases disposable income or poverty of families and children; (5) the proposed benefits of the action justify the financial impact on the family; (6) the action may be carried out by State or local government or by the family; and whether (7) the action establishes an implicit or explicit policy concerning the relationship between the behavior and personal responsibility of youth, and the norms of society.

DOE has considered how the benefits of this rule compare to the possible financial impact on a family (the only factor listed that is relevant to this rule). As part of its rulemaking process, DOE must determine whether the energy conservation standards contained in this final rule are economically justified. As discussed in section V.C.1, DOE has determined that the standards are economically justified because the benefits to consumers far outweigh the costs to manufacturers. Families will also see LCC savings as a result of this rule. Moreover, as discussed further in section V.B.1, DOE has determined that for the for low-income households, average LCC savings and PBP at the considered efficiency levels are improved (i.e., higher LCC savings and lower payback period) as compared to the average for all households. Further, the standards will also result in climate and health benefits for families.

I. Review Under Executive Order 12630

Pursuant to E.O. 12630, "Governmental Actions and Interference with Constitutionally Protected Property Rights," 53 FR 8859 (March 18, 1988), DOE has determined that this rule would not result in any takings that might require compensation under the Fifth Amendment to the U.S. Constitution.

J. Review Under the Treasury and General Government Appropriations Act, 2001

Section 515 of the Treasury and General Government Appropriations Act, 2001 (44 U.S.C. 3516, note) provides for Federal agencies to review most disseminations of information to the public under information quality guidelines established by each agency pursuant to general guidelines issued by OMB. OMB's guidelines were published at 67 FR 8452 (Feb. 22, 2002), and DOE's guidelines were published at 67 FR 62446 (Oct. 7, 2002). Pursuant to OMB Memorandum M-19-15, Improving Implementation of the Information Quality Act (April 24, 2019), DOE published updated guidelines which are available at *www.energy.gov/sites/prod/files/2019/12/f70/DOE%20Final%20Updated%20IQA%20Guidelines%20Dec%202019.pdf*. DOE has reviewed this final rule under the OMB and DOE guidelines and has concluded that it is consistent with applicable policies in those guidelines.

K. Review Under Executive Order 13211

E.O. 13211, "Actions Concerning Regulations That Significantly Affect Energy Supply, Distribution, or Use," 66 FR 28355 (May 22, 2001), requires Federal agencies to prepare and submit to OIRA at OMB, a Statement of Energy Effects for any significant energy action. A "significant energy action" is defined as any action by an agency that promulgates or is expected to lead to promulgation of a final rule, and that (1) is a significant regulatory action under Executive Order 12866, or any successor order; and (2) is likely to have a significant adverse effect on the supply, distribution, or use of energy, or (3) is designated by the Administrator of OIRA as a significant energy action.

For any significant energy action, the agency must give a detailed statement of any adverse effects on energy supply, distribution, or use should the proposal be implemented, and of reasonable alternatives to the action and their expected benefits on energy supply, distribution, and use.

DOE has concluded that this regulatory action, which sets forth new and amended energy conservation standards for consumer water heaters, is not a significant energy action because the standards are not likely to have a significant adverse effect on the supply, distribution, or use of energy, nor has it been designated as such by the Administrator at OIRA. Accordingly, DOE has not prepared a Statement of Energy Effects on this final rule.

L. Information Quality

On December 16, 2004, OMB, in consultation with the Office of Science and Technology Policy ("OSTP"), issued its Final Information Quality Bulletin for Peer Review ("the Bulletin"). 70 FR 2664 (Jan. 14, 2005). The Bulletin establishes that certain scientific information shall be peer reviewed by qualified specialists before it is disseminated by the Federal Government, including influential scientific information related to agency regulatory actions. The purpose of the Bulletin is to enhance the quality and credibility of the Government's scientific information. Under the Bulletin, the energy conservation standards rulemaking analyses are "influential scientific information," which the Bulletin defines as "scientific information the agency reasonably can determine will have, or does have, a clear and substantial impact on important public policies or private sector decisions." 70 FR 2664, 2667.

In response to OMB's Bulletin, DOE conducted formal peer reviews of the energy conservation standards development process and the analyses that are typically used and prepared a report describing that peer review.[211] Generation of this report involved a rigorous, formal, and documented evaluation using objective criteria and qualified and independent reviewers to make a judgment as to the technical/scientific/business merit, the actual or anticipated results, and the productivity and management effectiveness of programs and/or projects. Because available data, models, and technological understanding have changed since 2007, DOE has engaged with the National Academy of Sciences to review DOE's analytical methodologies to ascertain whether modifications are needed to improve DOE's analyses. DOE is in the process of evaluating the resulting report.[212]

M. Congressional Notification

As required by 5 U.S.C. 801, DOE will report to Congress on the promulgation of this rule prior to its effective date. The Office of Information and Regulatory Affairs has determined that this rule meets the criteria set forth in 5 U.S.C. 804(2).

[211] The 2007 "Energy Conservation Standards Rulemaking Peer Review Report" is available at the following website: *energy.gov/eere/buildings/downloads/energy-conservation-standards-rulemaking-peer-review-report-0* (last accessed April 1, 2023).
[212] The report is available at *www.nationalacademies.org/our-work/review-of-methods-for-setting-building-and-equipment-performance-standards*.

VII. Approval of the Office of the Secretary

The Secretary of Energy has approved publication of this final rule.

List of Subjects

10 CFR Part 429

Administrative practice and procedure, Confidential business information, Energy conservation, Household appliances, Reporting and recordkeeping requirements.

10 CFR Part 430

Administrative practice and procedure, Confidential business information, Energy conservation, Household appliances, Imports, Intergovernmental relations, Reporting and recordkeeping requirements, and Small businesses.

Signing Authority

This document of the Department of Energy was signed on April 24, 2024, by Jeffrey Marootian Principal Deputy Assistant Secretary for Energy Efficiency and Renewable Energy, pursuant to delegated authority from the Secretary of Energy. That document with the original signature and date is maintained by DOE. For administrative purposes only, and in compliance with requirements of the Office of the Federal Register, the undersigned DOE Federal Register Liaison Officer has been authorized to sign and submit the document in electronic format for publication, as an official document of the Department of Energy. This administrative process in no way alters the legal effect of this document upon publication in the *Federal Register*.

Signed in Washington, DC, on April 24, 2024.

X Jeffrey M. Maroootian

Digitally signed by Jeffrey M. Marootian
Date: 2024.04.24 14:43:47 -04'00'

Jeffrey Marootian
Principal Deputy Assistant Secretary for
Energy Efficiency and Renewable Energy
U.S. Department of Energy

For the reasons set forth in the preamble, DOE amends parts 429 and 430 of chapter II, subchapter D, of title 10 of the Code of Federal Regulations, as set forth below:

PART 429 – CERTIFICATION, COMPLIANCE, AND ENFORCEMENT FOR CONSUMER PRODUCTS AND COMMERCIAL AND INDUSTRIAL EQUIPMENT

1. The authority citation for part 429 continues to read as follows:

Authority: 42 U.S.C. 6291-6317; 28 U.S.C. 2461 note.

2. Amend §429.17 by revising paragraph (a)(1)(ii)(C) and adding paragraph (a)(1)(ii)(E) to read as follows:

§ 429.17 Water heaters.

(a) * * *

(1) * * *

(ii) * * *

(C) Any represented value of the rated storage volume must be equal to the mean of the measured storage volumes of all the units within the sample. Any represented value of the effective storage volume must be equal to the mean of the effective storage volumes of all the units within the sample.

* * * * *

(E) For an electric storage water heater that has a permanent mode or setting in which it is capable of heating and storing water above 135 °F, where permanent mode or setting means a mode of operation that is continuous and does not require any external consumer intervention to maintain for longer than 120 hours, except for those that meet the definition of "heat pump-type" water heater at §430.2 of this chapter, whose rated storage volumes are less than 20 gallons or greater than 55 gallons, or that are only capable of heating the stored water above 135 °F in response to instructions received from a utility or third-party demand-response program, the following applies:

(1) To demonstrate compliance with the energy conservation standards in §430.32(d)(1) of this chapter, any represented value of uniform energy factor shall be determined based on testing in accordance with section 5.1.1 of appendix E to subpart B of 10 CFR part 430.

(2) To demonstrate compliance with the energy conservation standards in §430.32(d)(2) of this chapter, any represented value of uniform energy factor shall be determined based on high temperature testing in accordance with section 5.1.2 of appendix E to subpart B of 10 CFR part 430.

* * * * *

3. Amend §429.134 by adding paragraph (d)(4) to read as follows:

§ 429.134 Product-specific enforcement provisions.

* * * * *

(d) * * *

(4) *Circulating water heaters*. A storage tank for testing will be selected as described in paragraphs (d)(4)(i) and (d)(4)(ii) of this section. The effective storage volume of the circulating water heater determined in testing will be measured in accordance with appendix E to subpart B of 10 CFR part 430 with the storage tank that is used for testing.

(i) *Electric heat pump circulating water heaters*. For UEF and first-hour rating testing, electric heat pump circulating water heaters will be tested with a minimally-compliant electric storage water heater (as defined at §430.2 of this chapter) that has a rated storage volume of between 25 and 35 gallons, and is in the low draw pattern, as determined in accordance with appendix E to subpart B of 10 CFR part 430 and the standards set at §430.32(d) of this chapter. If the manufacturer certifies the specific model of electric storage water heater used for testing to determine the certified UEF and first-hour rating of the electric heat pump circulating water heater, that model of electric storage water heater will be used for testing. If this is not possible (such as if the electric storage water heater model is no longer available or has been discontinued), testing will be performed with an electric storage water heater that has a minimally-compliant UEF rating, in the low draw pattern, and a rated storage volume that is within ± 3 gallons of the rated storage volume of the electric storage water heater used to determine the certified ratings of the electric heat pump circulating water heater (but not less than 25 gallons and not greater than 35 gallons). If no such model is available, then testing will be performed with a minimally-compliant electric storage water heater that has a rated storage volume of between 25 and 35 gallons and is in the low draw pattern.

(ii) *All other circulating water heaters*. For UEF and first-hour rating testing, circulating water heaters are paired with unfired hot water storage tanks ("UFHWSTs") that have certified storage volumes between 80 and 120 gallons and are at exactly the minimum thermal insulation standard, in terms of R-value, for UFHWSTs, as per the standards set at § 431.110(a) of this chapter. Testing will be performed as follows:

(A) If the manufacturer certifies the specific model of UFHWST used for testing to determine the certified UEF and first-hour rating of the circulating water heater, that model of UFHWST will be used for testing.

(B) If it is not possible to perform testing with the same model of UFHWST certified by the manufacturer, testing will be carried out with a different model of UFHWST accordingly:

(1) Testing will be performed with an UFHWST from the same manufacturer as the certified UFHWST, with the same certified storage volume as the certified UFHWST, and with a certified R-value that meets but does not exceed the standard set at §431.110(a) of this chapter. If this is not possible,

(2) Testing will be performed with an UFHWST from a different manufacturer than the certified UFHWST, with the same certified storage volume as the certified UFHWST, and with a certified R-

value that meets but does not exceed the standard set at §431.110(a) of this chapter. If this is not possible,

(3) Testing will be performed with an UFHWST from the same manufacturer as the certified UFHWST, having a certified storage volume within ±5 gallons of the certified UFHWST, and with a certified R-value that meets but does not exceed the standard set at §431.110(a) of this chapter. If this is not possible,

(4) Testing will be performed with an UFHWST from a different manufacturer than the certified UFHWST, having a certified storage volume within ±5 gallons of the certified UFHWST, and with a certified R-value that meets but does not exceed the standard set at §431.110(a) of this chapter. If this is not possible,

(5) Testing will be performed with an UFHWST having a certified storage volume between 80 gallons and 120 gallons and with a certified R-value that meets but does not exceed the standard set at §431.110(a) of this chapter.

* * * * *

PART 430 – ENERGY CONSERVATION PROGRAM FOR CONSUMER PRODUCTS

4. The authority citation for part 430 continues to read as follows:

Authority: 42 U.S.C. 6291-6309; 28 U.S.C. 2461 note.

5. Amend §430.2 by:

a. Revising the definition of "Circulating water heater";

b. Adding in alphabetical order the definitions of: "Electric circulating water heater", "Gas-fired circulating water heater", and "Oil-fired circulating water heater"; and

c. Revising the definition of "Tabletop water heater".

The revisions and additions read as follows:

§ 430.2 Definitions.

* * * * *

Circulating water heater means a water heater that does not have an operational scheme in which the burner, heating element, or compressor initiates and/or terminates heating based on sensing flow; has a water temperature sensor located at the inlet or the outlet of the water heater or in a separate storage tank that is the primary means of initiating and terminating heating; and must be used in combination with a recirculating pump to circulate water and either a separate storage tank or water circulation loop in order to achieve the water flow and temperature conditions recommended in the manufacturer's installation and operation instructions. A circulating water heater constitutes a storage-type water heater.

* * * * *

Electric circulating water heater means a circulating water heater with an input of 12 kW or less (including heat pump-only units with power inputs of no more than 24 A at 250 V).

*   *   *   *   *

Gas-fired circulating water heater means a circulating water heater with a nominal input of 75,000 Btu/h or less.

*   *   *   *   *

Oil-fired circulating water heater means a circulating water heater with a nominal input of 105,000 Btu/h or less.

*   *   *   *   *

Tabletop water heater means a water heater in a rectangular box enclosure designed to slide into a kitchen countertop space with typical dimensions of 36 inches high, 25 inches deep, and 24 inches wide, and with a certified first-hour rating that results in either the very small draw pattern or the low draw pattern, as specified in Table I in section 5.4.1 of appendix E to subpart B of this part.

*   *   *   *   *

6. Amend §430.23 by revising paragraph (e) to read as follows:

§ 430.23 Test procedures for measurement of energy and water consumption

*   *   *   *   *

(e) *Water heaters*.

(1) The estimated annual operating cost is calculated as:

(i) For a gas-fired or oil-fired water heater, the sum of: The product of the annual gas or oil energy consumption, determined according to section 6.3.11 or 6.4.7 of appendix E to this subpart, times the representative average unit cost of gas or oil, as appropriate, in dollars per Btu as provided by the Secretary; plus the product of the annual electric energy consumption, determined according to section 6.3.10 or 6.4.6 of appendix E to this subpart, times the representative average unit cost of electricity in dollars per kilowatt-hour as provided by the Secretary. Round the resulting sum to the nearest dollar per year.

(ii) For an electric water heater, the product of the annual energy consumption, determined according to section 6.3.10 or 6.4.6 of appendix E to this subpart, times the representative average unit cost of electricity in dollars per kilowatt-hour as provided by the Secretary. Round the resulting product to the nearest dollar per year.

(2) For an individual unit, the uniform energy factor is rounded to the nearest 0.01 and determined in accordance with section 6.3.8 or section 6.4.4 of appendix E to this subpart.

*   *   *   *   *

7. Amend Appendix E to subpart B of part 430 by:

a. Revising the Note;

b. Revising section 1.19;

c. Revising section 4.10; and

d. Revising sections 5.1.2 and 5.2.1.

The revisions read as follows:

APPENDIX E TO SUBPART B OF PART 430—UNIFORM TEST METHOD FOR MEASURING THE ENERGY CONSUMPTION OF WATER HEATERS

Note: Prior to December 18, 2023, representations with respect to the energy use or efficiency of consumer water heaters covered by this test method, including compliance certifications, must be based on testing conducted in accordance with either this appendix as it now appears or appendix E as it appeared at 10 CFR part 430, subpart B revised as of January 1, 2021. Prior to June 15, 2024, representations with respect to the energy use or efficiency of residential-duty commercial water heaters covered by this test method, including compliance certifications, must be based on testing conducted in accordance with either this appendix as it now appears or appendix E as it appeared at 10 CFR part 430, subpart B revised as of January 1, 2021.

On and after December 18, 2023, representations with respect to energy use or efficiency of consumer water heaters covered by this test method, including compliance certifications, must be based on testing conducted in accordance with this appendix, except as described in the paragraphs that follow. On and after June 15, 2024, representations with respect to energy use or efficiency of residential-duty commercial water heaters covered by this test method, including compliance certifications, must be based on testing conducted in accordance with this appendix, except as follows.

Prior to [**INSERT DATE 5 YEARS AFTER DATE OF PUBLICATION IN THE *FEDERAL REGISTER***], consumer water heaters subject to section 4.10 of this appendix may optionally apply the requirements of section 4.10 of this appendix. For residential-duty commercial water heaters subject to section 4.10 of this appendix the requirements of section 4.10 of this appendix may optionally be applied prior to the compliance date of any final rule reviewing potential amended energy conservation standards for this equipment published after June 21, 2023.

Prior to [**INSERT DATE 5 YEARS AFTER DATE OF PUBLICATION IN THE *FEDERAL REGISTER***], consumer water heaters subject to section 5.1.2 of this appendix (as specified at §429.17(a)(1)(ii)(E) of this chapter) may optionally apply the requirements of section 5.1.2 of this appendix in lieu of the requirements in section 5.1.1 of this appendix.

On or after [**INSERT DATE OF5 YEARS AFTER DATE OF PUBLICATION IN THE *FEDERAL REGISTER***], representations with respect to energy use or efficiency of consumer water heaters subject to section 4.10 and section 5.1.2 of this appendix must be based on testing conducted in accordance with those provisions.

*   *   *   *   *

1.19 *Water Heater Requiring a Storage Tank* means a water heater without a storage tank supplied by the manufacturer that cannot meet the requirements of sections 2 and 5 of this appendix without the use of a storage water heater or unfired hot water storage tank.

*   *   *   *   *

4.10 *Storage Tank Requirement for Water Heaters Requiring a Storage Tank (i.e., Circulating Water Heaters).* On or after [**INSERT DATE 5 YEARS AFTER DATE OF PUBLICATION IN THE *FEDERAL REGISTER***], when testing a gas-fired, oil-fired, or electric resistance circulating water heater (*i.e.*, any circulating water heater that does not use a heat pump), the tank to be used for testing shall be an unfired hot water storage tank having volume between 80 and 120 gallons (364-546 liters) determined using the method specified in section 5.2.1 that meets but does not exceed the minimum energy conservation standards required according to §431.110 of this chapter. When testing a heat pump circulating water heater, the tank to be used for testing shall be an electric storage water heater that has a measured volume of 30 gallons (±5 gallons), has a First-Hour Rating less than 51 gallons resulting in classification under the low draw pattern, and has a rated UEF equal to the minimum UEF standard specified at § 430.32(d), rounded to the nearest 0.01. The operational mode of the heat pump circulating water heater and storage water heater paired system shall be set in accordance with section 5.1.1 of this appendix. If the circulating water heater is supplied with a separate non-integrated circulating pump, install this pump as per the manufacturer's installation instructions and include its power consumption in energy use measurements.

* * * * *

5.1.2

High Temperature Testing. This paragraph applies to electric storage water heaters capable of achieving a $T_{max,1}$ above 135 °F. The following exceptions apply:

(1) Electric storage water heaters that do not have a permanent mode or setting in which the water heater is capable of heating and storing water above 135 °F (as measured by $T_{max,1}$), where permanent mode or setting means a mode of operation that is continuous and does not require any external consumer intervention to maintain for longer than 120 hours;

(2) Electric storage water heaters that meet the definition of "heat pump-type" water heater at §430.2;

(3) Electric storage water heaters that are only capable of heating the stored water above 135 °F in response to instructions received from a utility or third-party demand-response program.

(4) Electric storage water heaters with measured storage volumes (V_{st}) less than 20 gallons or greater than 55 gallons.

This paragraph may optionally apply to electric heat pump water heaters for voluntary representations of high-temperature operation only.

For those equipped with factory-installed or built-in mixing valves, set the unit to maintain the highest mean tank temperature possible while delivering water at 125 °F ±5 °F. For those not so equipped, install an ASSE 1017-certified mixing valve in accordance with the provisions in section 4.3 of this appendix and adjust the valve to deliver water at 125 °F ±5 °F when the water heater is operating at its highest storage tank temperature setpoint. Maintain this setting throughout the entirety of the test.

* * * * *

5.2.1 *Determination of Storage Tank Volume.* For water heaters and separate storage tanks used for testing circulating water heaters, determine the storage capacity, V_{st}, of the water heater or separate storage tank under test, in gallons (liters), by subtracting the tare weight, W_t, (measured while the tank is empty) from the gross weight of the storage tank when completely filled with water at the supply water temperature specified in section 2.3 of this appendix, W_f, (with all air eliminated and line pressure applied as described in section 2.6 of this appendix) and dividing the resulting net weight by the density of water at the measured temperature.

* * * * *

8. Amend § 430.32 by revising paragraph (d) to read as follows:

§ 430.32 Energy and water conservation standard and their compliance dates.

* * * * *

(d) *Water Heaters.*

(1) The uniform energy factor of water heaters manufactured before [**INSERT DATE 5 YEARS AFTER DATE OF PUBLICATION IN THE *FEDERAL REGISTER***] shall not be less than the following:

Product Class	Rated Storage Volume and Input Rating *(if applicable)*	Draw Pattern	Uniform Energy Factor*
Gas-fired Storage Water Heater	≥20 gal and ≤55 gal	Very Small	$0.3456 - (0.0020 \times V_r)$
		Low	$0.5982 - (0.0019 \times V_r)$
		Medium	$0.6483 - (0.0017 \times V_r)$
		High	$0.6920 - (0.0013 \times V_r)$
	>55 gal and ≤100 gal	Very Small	$0.6470 - (0.0006 \times V_r)$
		Low	$0.7689 - (0.0005 \times V_r)$
		Medium	$0.7897 - (0.0004 \times V_r)$
		High	$0.8072 - (0.0003 \times V_r)$
Oil-fired Storage Water Heater	≤50 gal	Very Small	$0.2509 - (0.0012 \times V_r)$
		Low	$0.5330 - (0.0016 \times V_r)$
		Medium	$0.6078 - (0.0016 \times V_r)$
		High	$0.6815 - (0.0014 \times V_r)$
Electric Storage Water Heaters	≥20 gal and ≤55 gal	Very Small	$0.8808 - (0.0008 \times V_r)$
		Low	$0.9254 - (0.0003 \times V_r)$
		Medium	$0.9307 - (0.0002 \times V_r)$
		High	$0.9349 - (0.0001 \times V_r)$
	>55 gal and ≤120 gal	Very Small	$1.9236 - (0.0011 \times V_r)$
		Low	$2.0440 - (0.0011 \times V_r)$
		Medium	$2.1171 - (0.0011 \times V_r)$
		High	$2.2418 - (0.0011 \times V_r)$
Tabletop Water Heater	≥20 gal and ≤120 gal	Very Small	$0.6323 - (0.0058 \times V_r)$
		Low	$0.9188 - (0.0031 \times V_r)$
		Medium	$0.9577 - (0.0023 \times V_r)$
		High	$0.9884 - (0.0016 \times V_r)$
Instantaneous Gas-fired Water Heater	<2 gal and >50,000 Btu/h	Very Small	0.80
		Low	0.81
		Medium	0.81
		High	0.81
Instantaneous Electric Water Heater	<2 gal	Very Small	0.91
		Low	0.91
		Medium	0.91
		High	0.92
Grid-enabled Water Heater	>75 gal	Very Small	$1.0136 - (0.0028 \times V_r)$
		Low	$0.9984 - (0.0014 \times V_r)$
		Medium	$0.9853 - (0.0010 \times V_r)$
		High	$0.9720 - (0.0007 \times V_r)$

* V_r is the rated storage volume (in gallons), as determined pursuant to §429.17 of this chapter.

(2) The uniform energy factor of water heaters manufactured on or after [**INSERT DATE 5 YEARS AFTER DATE OF PUBLICATION IN THE *FEDERAL REGISTER***] shall not be less than the following:

Product Class	**Effective Storage Volume and Input Rating** *(if applicable)*	**Draw Pattern**	**Uniform Energy Factor***
Gas-fired Storage Water Heater	< 20 gal	Very Small	0.2062 − (0.0020 x V_{eff})
		Low	0.4893 − (0.0027 x V_{eff})
		Medium	0.5758 − (0.0023 x V_{eff})
		High	0.6586 − (0.0020 x V_{eff})
	≥20 gal and ≤55 gal	Very Small	0.3925 − (0.0020 × V_{eff})
		Low	0.6451 − (0.0019 × V_{eff})
		Medium	0.7046 − (0.0017 × V_{eff})
		High	0.7424 − (0.0013 × V_{eff})
	>55 gal and ≤100 gal	Very Small	0.6470 − (0.0006 x V_{eff})
		Low	0.7689 − (0.0005 x V_{eff})
		Medium	0.7897 − (0.0004 x V_{eff})
		High	0.8072 − (0.0003 x V_{eff})
	> 100 gal	Very Small	0.1482 − (0.0007 x V_{eff})
		Low	0.4342 − (0.0017 x V_{eff})
		Medium	0.5596 − (0.0020 x V_{eff})
		High	0.6658 − (0.0019 x V_{eff})
Oil-fired Storage Water Heater	≤50 gal	Very Small	0.2909 − (0.0012 × V_{eff})
		Low	0.5730 − (0.0016 × V_{eff})
		Medium	0.6478 − (0.0016 × V_{eff})
		High	0.7215 − (0.0014 × V_{eff})
	> 50 gal	Very Small	0.1580 − (0.0009 x V_{eff})
		Low	0.4390 − (0.0020 x V_{eff})
		Medium	0.5389 − (0.0021 x V_{eff})
		High	0.6172 − (0.0018 x V_{eff})

Product Class	**Effective Storage Volume and Input Rating** *(if applicable)*	**Draw Pattern**	**Uniform Energy Factor***
Very Small Electric Storage Water Heater	< 20 gal	Very Small	$0.5925 - (0.0059 \times V_{eff})$
		Low	$0.8642 - (0.0030 \times V_{eff})$
		Medium	$0.9096 - (0.0020 \times V_{eff})$
		High	$0.9430 - (0.0012 \times V_{eff})$
Small Electric Storage Water Heater	≥20 gal and ≤35 gal	Very Small	$0.8808 - (0.0008 \times V_{eff})$
		Low	$0.9254 - (0.0003 \times V_{eff})$
Electric Storage Water Heaters	≥20 and ≤ 55 gal (excluding small electric storage water heaters)	Very Small	2.30
		Low	2.30
		Medium	2.30
		High	2.30
	>55 gal and ≤120 gal	Very Small	2.50
		Low	2.50
		Medium	2.50
		High	2.50
	>120 gal	Very Small	$0.3574 - (0.0012 \times V_{eff})$
		Low	$0.7897 - (0.0019 \times V_{eff})$
		Medium	$0.8884 - (0.0017 \times V_{eff})$
		High	$0.9575 - (0.0013 \times V_{eff})$
Tabletop Water Heater	<20 gal	Very Small	$0.5925 - (0.0059 \times V_{eff})$
		Low	$0.8642 - (0.0030 \times V_{eff})$
	≥20 gal	Very Small	$0.6323 - (0.0058 \times V_{eff})$
		Low	$0.9188 - (0.0031 \times V_{eff})$
Instantaneous Oil-fired Water Heater	<2 gal and ≤210,000 Btu/h	Very Small	0.61
		Low	0.61
		Medium	0.61
		High	0.61
	≥2 gal and ≤210,000 Btu/h	Very Small	$0.2780 - (0.0022 \times V_{eff})$
		Low	$0.5151 - (0.0023 \times V_{eff})$
		Medium	$0.5687 - (0.0021 \times V_{eff})$

Product Class	Effective Storage Volume and Input Rating *(if applicable)*	Draw Pattern	Uniform Energy Factor*
		High	$0.6147 - (0.0017 \times V_{eff})$
Instantaneous Electric Water Heater	<2 gal	Very Small	0.91
		Low	0.91
		Medium	0.91
		High	0.92
	≥2 gal	Very Small	$0.8086 - (0.0050 \times V_{eff})$
		Low	$0.9123 - (0.0020 \times V_{eff})$
		Medium	$0.9252 - (0.0015 \times V_{eff})$
		High	$0.9350 - (0.0011 \times V_{eff})$
Grid-Enabled Water Heater	>75 gal	Very Small	$1.0136 - (0.0028 \times V_{eff})$
		Low	$0.9984 - (0.0014 \times V_{eff})$
		Medium	$0.9853 - (0.0010 \times V_{eff})$
		High	$0.9720 - (0.0007 \times V_{eff})$

* V_{eff} is the Effective Storage Volume (in gallons), as determined pursuant to §429.17 of this chapter.

(3) The provisions of paragraph (d) of this section are separate and severable from one another. Should a court of competent jurisdiction hold any provision(s) of paragraph (d) of this section to be stayed or invalid, such action shall not affect any other provision of paragraph (d) of this section.

*   *   *   *   *

Note: The following letter will not appear in the Code of Federal Regulations.

October 12, 2023

U.S. DEPARTMENT OFJUSTICE

Antitrust Division

Ami Grace-Tardy

Assistant General Counsel

for Legislation, Regulation and Energy Efficiency

U.S. Department of Energy

Washington, DC 20585

Re: Energy Conservation Standards for Consumer Water Heaters DOE Docket No. EERE-2017-BT-STD-0019

Dear Assistant General Counsel Grace-Tardy:

I am responding to your August 23, 2023 letter seeking the views of the Attorney General about the potential impact on competition of proposed energy conservation standards for consumer water heaters.

Your request was submitted under Section 325(o)(2)(B)(i)(V) of the Energy Policy and Conservation Act, as amended (ECPA), 42 U.S.C. 6295(o)(2)(B)(i)(V), which requires the Attorney General to determine the impact of any lessening of competition that is likely to result from the imposition of proposed energy conservation standards.

The Attorney General's responsibility for responding to requests from other departments about the effect of a program on competition has been delegated to the Assistant Attorney General for the Antitrust Division in 28 CFR § 0.40(g). The Assistant Attorney General for the Antitrust Division has authorized me, as the Policy Director for the Antitrust Division, to provide the Antitrust Division's views regarding the potential impact on competition of proposed energy conservation standards on his behalf.

In conducting its analysis, the Antitrust Division examines whether a proposed standard may lessen competition, for example, by substantially limiting consumer choice, by placing certain manufacturers at an unjustified competitive disadvantage, or by inducing avoidable inefficiencies in production or distribution of particular products. A lessening of competition could result in higher prices to manufacturers and consumers.

We have reviewed the proposed standards contained in the notice of proposed rulemaking ("NOPR") (88 Fed. Reg. 49058, July 28, 2023) and the related Technical Support Document. We have also reviewed public comments and information provided by industry participants and have reviewed the transcript and information presented at the Webinar of the Public Meeting held on September 13, 2023. Based on this review, we do not have an evidentiary basis to conclude that the proposed energy conservation standards for consumer water heaters are likely to substantially lessen competition.

Sincerely,

David G.B. Lawrence

Policy Director