This document, concerning Commercial Water Heating Equipment is an action issued by the U.S. Department of Energy (DOE). 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.

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[6450-01-P]

DEPARTMENT OF ENERGY

10 CFR Part 431

[EERE-2021-BT-STD-0027]

RIN 1904-AD34

Energy Conservation Program: Energy Conservation Standards for Commercial Water Heating Equipment

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 Commercial Water Heating ("CWH") equipment. EPCA also requires the U.S. Department of Energy ("DOE") to periodically review standards. In this final rule, DOE is adopting amended energy conservation standards for CWH equipment.

DATES: The effective date of this rule is **[INSERT DATE 60 DAYS AFTER DATE OF PUBLICATION IN THE *FEDERAL REGISTER*]**. Compliance with the amended standards established for CWH equipment in this final rule is required on and after [**INSERT DATE 3 YEARS AFTER DATE OF PUBLICATION IN THE *FEDERAL REGISTER***].

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-2021-BT-STD-0027*. The docket webpage contains instructions on how to access all documents, including public comments, in the docket.

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*.

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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 C of EPCA,[2] established the Energy Conservation Program for Certain Industrial Equipment. (42 U.S.C. 6311-6317) Such equipment includes CWH equipment, the subject of this rulemaking.

[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 C was re-designated Part A-1.

Pursuant to EPCA, DOE is to consider amending the energy efficiency standards for certain types of commercial and industrial equipment, including the equipment at issue in this document, whenever the American Society of Heating, Refrigerating, and Air-Conditioning Engineers ("ASHRAE") amends the standard levels or design requirements prescribed in ASHRAE Standard 90.1, "Energy Standard for Buildings Except Low-Rise Residential Buildings," ("ASHRAE Standard 90.1"), and at a minimum, every 6 years. (42 U.S.C. 6313(a)(6)(A)-(C))

In accordance with these and other statutory provisions discussed in this document, DOE analyzed the benefits and burdens of trial standard levels (TSLs) for CWH equipment. The TSLs and their associated benefits and burdens are discussed in detail in sections V.A-C of this section. As discussed in section V.C of this section, DOE has determined that TSL 3 represents the maximum improvement in energy efficiency that is technologically feasible and economically justified. DOE is adopting amended energy conservation standards for certain classes of CWH equipment. The adopted standards, which are expressed in terms of thermal efficiency, standby loss, and uniform energy factor ("UEF"), are shown in Table I.1 and Table I.2. These adopted standards apply to all CWH equipment listed in Table I.1 and Table I.2, manufactured in, or imported into the United States starting on the date 3 years after the publication of the final rule for this rulemaking. DOE is also codifying standards for electric instantaneous CWH equipment from EPCA into the Code of Federal Regulations ("CFR"). Finally, DOE is amending the footnotes to tables of energy conservation standards at 10 CFR 431.110 to clarify existing regulations for CWH equipment. The adopted standards for electric instantaneous CWH equipment and changes to the footnotes are also shown in Table I.1.

Table I.1 Adopted Energy Conservation Standards for Commercial Water Heating Equipment Except for Residential-Duty Commercial Water Heaters

Equipment	Size	Energy Conservation Standards[a]	
		Minimum Thermal Efficiency[b]	Maximum Standby Loss **
Gas-fired storage water heaters and storage-type instantaneous water heaters	All	95%	$0.86 \times [Q/800 + 110(V_r)^{1/2}]$ (Btu/h)
Electric instantaneous water heaters[c]	<10 gal	80%	N/A
	≥10 gal	77%	$2.30 + 67/V_m$ (%/h)
Gas-fired instantaneous water heaters and hot water supply boilers except storage-type instantaneous water heaters	<10 gal	96%	N/A
	≥10 gal	96%	$Q/800 + 110(V_r)^{1/2}$ (Btu/h)

a. V_m is the measured storage volume, and V_r is the rated volume, both in gallons. Q is the rated input in Btu/h, as determined pursuant to 10 CFR 429.44.
b. Water heaters and hot water supply boilers having more than 140 gallons of storage capacity need not meet the standby loss requirement if: (1) the tank surface area is thermally insulated to R-12.5 or more, (2) a standing pilot light is not used, and (3) for gas or oil-fired storage water heaters, they have a flue damper or fan-assisted combustion.
c. The compliance date for these energy conservation standards is January 1, 1994.

Table I.2 Adopted Energy Conservation Standards for Gas-Fired Residential-Duty Commercial Water Heaters

Equipment	Specification*	Draw Pattern**	Uniform Energy Factor†
Gas-fired Residential-Duty Storage	>75 kBtu/h and ≤105 kBtu/h and ≤120 gal and ≤180 °F	Very Small	$0.5374 - (0.0009 \times V_r)$
		Low	$0.8062 - (0.0012 \times V_r)$
		Medium	$0.8702 - (0.0011 \times V_r)$
		High	$0.9297 - (0.0009 \times V_r)$

* Additionally, to be classified as a residential-duty water heater, a commercial water heater must meet the following conditions: (1) if requiring electricity, use single-phase external power supply; and (2) the water heater must not be designed to heat water at temperatures greater than 180 °F.
** Draw pattern is a classification of hot water use of a consumer water heater or residential-duty commercial water heater, based upon the first-hour rating. The draw pattern is determined using the *Uniform Test Method for Measuring the Energy Consumption of Water Heaters* in appendix E to subpart B of 10 CFR part 430.
† V_r is the rated storage volume (in gallons), as determined pursuant to 10 CFR 429.44.

A. Benefits and Costs to Consumers

Table I.3 summarizes DOE's evaluation of the economic impacts of the adopted standards on consumers of CWH equipment, as measured by the average life-cycle cost

("LCC") savings and the simple payback period ("PBP").[3] The analysis inputs are described in section IV of this document. The average LCC savings are positive for all equipment classes, and the PBP is less than the average lifetime of CWH equipment, which is estimated to range from 10 years for commercial gas-fired storage water heaters to 25 years for instantaneous water heaters and hot water supply boilers (see section IV.F.6 of this document).

Table I.3 Impacts of Adopted Energy Conservation Standards on Consumers of CWH Equipment

Equipment	Average LCC Savings *2022$*	Simple Payback Period *Years*
Commercial Gas-Fired Storage and Storage-Type Instantaneous	367	5.8
Residential-Duty Gas-Fired Storage	119	7.2
Gas-Fired Instantaneous Water Heaters and Hot Water Supply Boilers	898	9.3
– Instantaneous, Gas-Fired Tankless	120	8.9
– Instantaneous Water Heaters and Hot Water Supply Boilers	1,570	9.4

DOE's analysis of the impacts of the adopted standards on consumers is described in section IV.F 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 (2023–2055). Using a real discount rate of 9.1 percent, DOE estimates that the INPV for manufacturers of CWH equipment in the case without amended standards is $212.8 million in 2022$.

[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.8 of this document). The simple PBP, which is designed to compare specific efficiency levels, is measured relative to the baseline product (see section IV.F.9 of this document).

Under the adopted standards, the change in INPV is estimated to range from -17.7 percent to -8.3 percent, which is approximately equivalent to a decrease of $37.6 million to a decrease of $17.7 million, respectively. In order to bring products into compliance with amended standards, it is estimated that the industry would incur total conversion costs of $42.7 million.

DOE's analysis of the impacts of the adopted standards on manufacturers is described in section IV.J of this document. The analytic results of the manufacturer impact analysis ("MIA") are presented in section V.B.2 of this document.

C. National Benefits and Costs[4]

DOE's analyses indicate that the adopted energy conservation standards for CWH equipment would save a significant amount of energy. Relative to the case without amended standards, the lifetime energy savings for CWH equipment purchased in the 30-year period that begins in the anticipated year of compliance with the amended standards (2026–2055) amount to 0.70 quadrillion British thermal units ("Btu"), or quads.[5] This represents a savings of 5.6 percent relative to the energy use of 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 CWH equipment ranges from $0.43 billion (at a 7-percent discount rate) to $1.43 billion (at a 3-percent discount rate). This NPV expresses the estimated total value

[4] All monetary values in this document are expressed in 2022 dollars, and, where appropriate, are discounted to 2023 unless explicitly stated otherwise.
[5] The quantity refers to full-fuel-cycle ("FFC") energy savings. FFC energy savings include 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.2 of this document.

of future operating cost savings minus the estimated increased product and installation costs for CWH equipment purchased in 2026–2055.

In addition, the adopted standards for CWH equipment are projected to yield significant environmental benefits. DOE estimates that the standards would result in cumulative emission reductions (over the same period as for energy savings) of 38 million metric tons ("Mt")[6] of carbon dioxide ("CO_2"), 0.10 thousand tons of sulfur dioxide ("SO_2"), 103 thousand tons of nitrogen oxides ("NO_X"), 479 thousand tons of methane ("CH_4"), 0.08 thousand tons of nitrous oxide ("N_2O"), and -0.001 tons of mercury ("Hg").[7] The estimated cumulative reduction in CO_2 emissions through 2030 amounts to 1.5 million metric tons, which is equivalent to the emissions resulting from the annual electricity use of more than 295,000 homes.

DOE estimates the value of climate benefits from a reduction in greenhouse gases using four different estimates of the "social cost of carbon" ("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 greenhouse gases ("SC-GHG").[8] DOE used interim SC-GHG values developed by an Interagency Working Group on the Social Cost of Greenhouse Gases ("IWG").[9] The derivation of these values is discussed in section IV.L.1 of this

[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* represents current federal and state legislation and final implementation of regulations as of the time of its preparation. See section IV.K for further discussion of *AEO2023* assumptions that effect air pollutant 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 Interagency Working Group on the Social Cost of Greenhouse Gases (IWG).

[9] See Interagency Working Group on Social Cost of Greenhouse Gases, Technical Support Document: Social Cost of Carbon, Methane, and Nitrous Oxide. Interim Estimates Under Executive Order 13990, Washington, D.C. February 2021. *www.whitehouse.gov/wp-content/uploads/2021/02/TechnicalSupportDocument_SocialCostofCarbonMethaneNitrousOxide.pdf?*

document. For presentational purposes, the climate benefits associated with the average SC-GHG at a 3-percent discount rate over the 30-year analysis period is $2.30 billion. DOE does not have a single central SC-GHG point estimate, and it emphasizes the importance and value of considering the benefits calculated using all four SC-GHG estimates.

DOE estimated the monetary health benefits from SO_2 and NO_X emissions reduction, using benefit per ton estimates from EPA's Benefits Mapping and Analysis Program, as discussed in section IV.L of this document.[10] DOE estimates the present value of the health benefits would be $1.36 billion using a 7-percent discount rate, and $3.29 billion using a 3-percent discount. DOE is currently only monetizing health benefits from changes in fine particulate matter ("$PM_{2.5}$") and (for NO_X) ozone precursors, but will continue to assess the ability to monetize other effects such as health benefits from reductions in direct $PM_{2.5}$ emissions.

Table I.4 summarizes the monetized benefits and costs expected to result from the standards for CWH equipment. 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. In the table, total benefits for both the 3-percent and 7-percent cases are presented using the average GHG social costs with 3-percent discount rate. DOE does not have a single central SC-GHG point estimate and it emphasizes the importance and value of considering the benefits calculated using all four

[10] *Estimating the Benefit per Ton of Reducing PM2.5 Precursors from 21 Sectors*. www.epa.gov/benmap/estimating-benefit-ton-reducing-pm25-precursors-21-sectors.

SC-GHG estimates. The estimated total net benefits using each of the four SC-GHG estimates are presented in section V.B.6 of this document.

Table I.4 Present Value of Monetized Benefits and Costs of Adopted Energy Conservation Standards for CWH Equipment (TSL 3)

Benefits	Billion 2022$
3% discount rate	
Consumer Operating Cost Savings	2.76
Climate Benefits*	2.30
Health Benefits**	3.29
Total Monetized Benefits†	8.35
Consumer Incremental Product Costs‡	1.33
Net Monetized Benefits	7.02
Change in Producer Cashflow (INPV‡‡)	(0.04) – (0.02)
7% discount rate	
Consumer Operating Cost Savings	1.28
Climate Benefits* (3% discount rate)	2.30
Health Benefits**	1.36
Total Monetized Benefits†	4.94
Consumer Incremental Product Costs‡	0.85
Net Monetized Benefits	4.09
Change in Producer Cashflow (INPV‡‡)	(0.04) – (0.02)

Benefits	Billion 2022$

Note: This table presents the present value of costs and benefits associated with commercial water heaters shipped in 2026−2055. These results include benefits (including climate and health benefits) to consumers which accrue after 2055 from the products shipped in 2026−2055. Numbers may not add due to rounding.
* Climate benefits are calculated using four different estimates of the SC-CO_2, SC-CH_4, and 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 final rule). 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 importance and 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 $PM_{2.5}$ 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.
‡‡ 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 NIA includes all impacts (both costs and benefits) along the distribution chain beginning with the increased costs to the manufacturer to manufacture the equipment and ending with the increase in price experienced by the consumer. DOE also separately conducts a detailed analysis on the impacts on manufacturers (the 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 9.1% 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 commercial water heaters, those values are -$38 million and -$18 million. DOE accounts for that range of likely impacts in analyzing whether a TSL is economically justified. See section V.C of this document. DOE is presenting the range of impacts to the INPV under two markup 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 Markup 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 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 $6.98 billion to $7.0 billion at 3-percent discount rate and would range from $4.05 billion to $4.07 billion at 7-percent discount rate. Parentheses () indicate negative values.

The benefits and costs of the adopted 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 monetized value of the benefits of GHG, NO_X, and SO_2 emission reductions, all annualized.[11]

The national operating 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 CWH equipment shipped in 2026–2055. The climate benefits associated with reduced GHG emissions achieved as a result of the adopted standards are also calculated based on the lifetime of CWH equipment shipped in 2026–2055. 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 SC-GHG values are presented for all four discount rates in section V.B.6. 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 final rule and the TSD for review. In its assessment letter responding to DOE, DOJ concluded that the proposed energy conservation standards for CWH equipment are unlikely to have a significant

[11] To convert the time-series of costs and benefits into annualized values, DOE calculated a present value in 2023, 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.*, 2030), and then discounted the present value from each year to 2023. The calculation uses discount rates of 3 and 7 percent for all costs and benefits except for the value of CO_2 reductions, for which DOE used case-specific discount rates, as shown in Table I.3. 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.

adverse impact on competition. DOE is publishing the Attorney General's assessment at the end of this final rule.

Table I.5 presents the total estimated monetized benefits and costs associated with the adopted standard, expressed in terms of annualized values.

Using a 7-percent discount rate for consumer benefits and costs and health benefits from reduced SO_2 and NOx emissions, and the 3-percent discount rate case for climate benefits from reduced GHG emissions, the estimated monetized cost of the standards adopted in this rule is $78 million per year in increased equipment costs, while the estimated annual benefits are $118 million in reduced equipment operating costs, $125 million in monetized climate benefits, and $125 million in monetized health benefits. In this case, the net monetized benefit would amount to $289 million per year.

Using a 3-percent discount rate for all benefits and costs, the estimated monetized cost of the standards is $72 million per year in increased equipment costs, while the estimated annual monetized benefits are $149 million in reduced operating costs, $125 million in monetized climate benefits, and $178 million in monetized air pollutant health benefits. In this case, the net benefit would amount to $380 million per year.

Table I.5 Annualized Monetized Benefits and Costs of Adopted Energy Conservation Standards for CWH Equipment (TSL 3)

Category	Million 2022$/year		
	Primary Estimate	**Low-Net-Benefits Estimate**	**High-Net-Benefits Estimate**
3% discount rate			
Consumer Operating Cost Savings	149	144	154
Climate Benefits*	125	124	128
Health Benefits**	178	177	197
Total Monetized Benefits†	452	445	479
Consumer Incremental Product Costs‡	72	72	74
Net Monetized Benefits	380	373	405
Change in Producer Cashflow (INPV‡‡)	(4) – (2)	(4) – (2)	(4) – (2)

Category	Million 2022$/year		
	Primary Estimate	Low-Net-Benefits Estimate	High-Net-Benefits Estimate
7% discount rate			
Consumer Operating Cost Savings	118	115	122
Climate Benefits* (3% discount rate)	125	124	128
Health Benefits**	125	124.4	138.1
Total Monetized Benefits†	368	364	388
Consumer Incremental Product Costs‡	78	78.2	80.0
Net Monetized Benefits	289	285	308
Change in Producer Cashflow (INPV‡‡)	(4) – (2)	(4) – (2)	(4) – (2)

Note: This table presents the annualized costs and benefits associated with CWH equipment shipped in 2026−2055. These results include benefits to consumers which accrue after 2055 from the products purchased in 2026−2055. 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. 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 final rule). 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 importance and 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 $PM_{2.5}$ 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 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 NIA includes all impacts (both costs and benefits) along the distribution chain beginning with the increased costs to the manufacturer to manufacture the equipment and ending with the increase in price experienced by the consumer. DOE also separately conducts a detailed analysis on the impacts on manufacturers (the 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 9.1% 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 commercial water heaters, those values are -$4 million and -$2 million. DOE accounts for that range of likely impacts in analyzing whether a TSL is economically justified. See section V.C of this document. DOE is presenting the range of impacts to the INPV under two markup 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 Markup 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, to provide additional context for assessing the estimated impacts of this 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 $376 million to $378 million at 3-percent discount rate and would range from $285 million to $287 million at 7-percent discount rate. Parentheses () indicate negative values.

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, based on clear and convincing evidence as presented in the following sections, that the standards adopted in this final rule are technologically feasible and economically justified, and would result in significant additional conservation of energy. Specifically, with regards to technological feasibility, CWH equipment achieving the adopted standard levels are already commercially available for all equipment classes covered by this final rule. As for economic justification, DOE's analysis shows that the benefits of the proposed standard exceed, to a great extent, the burdens of the adopted 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 monetized cost of the proposed standards for CWH equipment is $78 million per year in increased equipment costs, while the estimated annual monetized benefits are $118 million in reduced equipment operating costs, $125 million in monetized climate benefits from GHG reductions, and $125 million in monetized air pollutant health benefits. In this case, the net monetized benefit would amount to $289 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

[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).

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 full-fuel cycle ("FFC") national energy savings of 0.70 quad for equipment purchased in the 30-year period that begins in the anticipated year of compliance with the amended standards (2026–2055), the equivalent of the electricity use of approximately 28 million homes in 1 year. In addition, they are projected to reduce CO_2 emissions by 38 Mt. Based on these findings, 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. 6313(a)(6)(A)(ii)(II). 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 CWH equipment. CWH equipment includes storage water heaters, instantaneous water heaters, and unfired hot water storage tanks. Such equipment (besides unfired hot water storage tanks, which only store hot water) may use gas, oil, or electricity to heat potable water. CWH equipment generally have higher input ratings than residential water heaters and are used in a wide variety of applications (including restaurants, hotels, multi-family housing, schools, convention centers, etc.).

Some CWH equipment (in particular, residential-duty CWH) may also be used in certain residential applications.

A. Authority

EPCA authorizes DOE to regulate the energy efficiency of a number of consumer products and industrial equipment. Title III, Part C of EPCA, added by Pub. L. 95-619, Title IV, section 441(a) (42 U.S.C. 6311–6317, as codified), established the Energy Conservation Program for Certain Industrial Equipment, which sets forth a variety of provisions designed to improve energy efficiency. This equipment includes the classes of CWH equipment that are the subject of this final rule. (42 U.S.C. 6311(1)(K)) EPCA prescribed energy conservation standards for CWH equipment. (42 U.S.C. 6313(a)(5)) Pursuant to EPCA, DOE is to consider amending the energy efficiency standards for certain types of commercial and industrial equipment, including CWH equipment, whenever ASHRAE amends the standard levels or design requirements prescribed in ASHRAE/IES Standard 90.1, and at a minimum, every 6 years. (42 U.S.C. 6313(a)(6)(A)-(C))

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 EPCA specifically include definitions (42 U.S.C. 6311), energy conservation standards (42 U.S.C. 6313), test procedures (42 U.S.C. 6314), labeling provisions (42 U.S.C. 6315), and the authority to require information and reports from manufacturers (42 U.S.C. 6316).

Federal energy efficiency requirements for covered equipment established under EPCA generally supersede State laws and regulations concerning energy conservation testing, labeling, and standards. (42 U.S.C. 6316(a) and (b); 42 U.S.C. 6297) DOE may, however, grant waivers of Federal preemption for particular State laws or regulations, in accordance with the procedures and other provisions set forth under EPCA. (*See* 42 U.S.C. 6316(b)(2)(D))

Subject to certain criteria and conditions, DOE is required to develop test procedures to measure the energy efficiency, energy use, or estimated annual operating cost of covered equipment. Manufacturers of covered equipment must use the Federal test procedures as the basis for (1) certifying to DOE that their equipment complies with the applicable energy conservation standards adopted pursuant to EPCA (42 U.S.C. 6316(b); 42 U.S.C. 6296), and (2) making representations about the efficiency of that equipment (42 U.S.C. 6314(d)). Similarly, DOE uses these test procedures to determine whether the equipment complies with relevant standards promulgated under EPCA. The DOE test procedures for CWH equipment appear at part 431, subpart G.

ASHRAE Standard 90.1 sets industry energy efficiency levels for small, large, and very large commercial package air-conditioning and heating equipment, packaged terminal air conditioners, packaged terminal heat pumps, warm air furnaces, packaged boilers, storage water heaters, instantaneous water heaters, and unfired hot water storage tanks (collectively "ASHRAE equipment"). For each type of listed equipment, EPCA directs that if ASHRAE amends Standard 90.1, DOE must adopt amended standards at the new ASHRAE efficiency level, unless DOE determines, supported by clear and convincing evidence,[13] that adoption of a more stringent level would produce significant additional conservation of energy and would be technologically feasible and economically justified. (42 U.S.C. 6313(a)(6)(A)(ii)) Under EPCA, DOE must also review energy efficiency standards for CWH equipment every 6 years and either: (1) issue a notice of determination that the standards do not need to be amended as adoption of a more stringent level is not supported by clear and convincing evidence; or (2) issue a notice of proposed rulemaking including new proposed standards based on certain criteria and procedures in subparagraph (B) of 42 U.S.C. 6313(a)(6).[14] (42 U.S.C. 6313(a)(6)(C))

In deciding whether a more-stringent standard is economically justified, under either the provisions of 42 U.S.C. 6313(a)(6)(A) or 42 U.S.C. 6313(a)(6)(C), DOE must determine whether the benefits of the standard exceed its burdens. 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 products subject to the standard;

[13] The clear and convincing threshold is a heightened standard, and would only be met where the Secretary has an abiding conviction, based on available facts, data, and DOE's own analyses, that it is highly probable an amended standard would result in a significant additional amount of energy savings, and is technologically feasible and economically justified. *American Public Gas Association v. U.S. Dep't of Energy*, 22 F.4th 1018, 1025 (D.C. Cir. January 18, 2022) (citing *Colorado v. New Mexico*, 467 U.S. 310, 316, 104 S.Ct. 2433, 81 L.Ed.2d 247 (1984)).

[14] In relevant part, subparagraph (B) specifies that: (1) in making a determination of economic justification, DOE must consider, to the maximum extent practicable, the benefits and burdens of an amended standard based on the seven criteria described in EPCA; (2) DOE may not prescribe any standard that increases the energy use or decreases the energy efficiency of a covered product; and (3) DOE may not prescribe any standard that interested persons have established by a preponderance of evidence is likely to result in the unavailability in the United States of any 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. 6313(a)(6)(B)(ii)-(iii))

(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 equipment that are likely to result from the standard;

(3) The total projected amount of energy savings likely to result directly from the standard;

(4) Any lessening of the utility or the performance of the covered product 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 conservation; and

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

(42 U.S.C. 6313(a)(6)(B)(ii)(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 the standard will be less than three times the value of the energy (and, as applicable, water) 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)) However, while this rebuttable presumption analysis applies to most commercial and industrial equipment (42 U.S.C. 6316(a)), it is not a required analysis for ASHRAE equipment (42 U.S.C. 6316(b)(1)). Nonetheless, DOE included the analysis of rebuttable presumption in its economic analysis and presents the results in section V.B.1.c of this document.

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. 6313(a)(6)(B)(iii)(I)) 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. 6313(a)(6)(B)(iii)(II)(aa))

B. Background

1. Current Standards

The current standards for all CWH equipment classes are set forth in DOE's regulations at 10 CFR 431.110, except for electric instantaneous water heaters that are not residential duty, which are included in EPCA (the history of the standards for electric instantaneous water heaters is discussed in section III.B.3 of this document). (42 U.S.C. 6313(a)(5)(D)-(E)) Table II.1 shows the current standards for all CWH equipment classes, except residential-duty commercial water heaters, which are shown in Table II.2 of this document.

Table II.1 Current Federal Energy Conservation Standards for CWH Equipment Except for Residential-Duty Commercial Water Heaters

Product	Size	Energy Conservation Standards*	
		Minimum Thermal Efficiency (equipment manufactured on and after October 9, 2015)**,***	Maximum Standby Loss (equipment manufactured on and after October 29, 2003)**,†
Electric storage water heaters	All	N/A	$0.30 + 27/V_m$ (%/h)
Gas-fired storage water heaters	≤155,000 Btu/h	80%	$Q/800 + 110(V_r)^{1/2}$ (Btu/h)
	>155,000 Btu/h	80%	$Q/800 + 110(V_r)^{1/2}$ (Btu/h)
Oil-fired storage water heaters	≤155,000 Btu/h	80%***	$Q/800 + 110(V_r)^{1/2}$ (Btu/h)
	>155,000 Btu/h	80%***	$Q/800 + 110(V_r)^{1/2}$ (Btu/h)
Electric instantaneous water heaters‡	<10 gal	80%	N/A
	≥10 gal	77%	$2.30 + 67/V_m$ (%/h)
Gas-fired instantaneous water heaters and hot water supply boilers	<10 gal	80%	N/A
	≥10 gal	80%	$Q/800 + 110(V_r)^{1/2}$ (Btu/h)
Oil-fired instantaneous water heater and hot water supply boilers	<10 gal	80%	N/A
	≥10 gal	78%	$Q/800 + 110(V_r)^{1/2}$ (Btu/h)
		Minimum Thermal Insulation	
Unfired hot water storage tank	All	R-12.5	

* V_m is the measured storage volume, and V_r is the rated volume, both in gallons. Q is the nameplate input rate in Btu/h.
** For hot water supply boilers with a capacity of less than 10 gallons: (1) the standards are mandatory for products manufactured on and after October 21, 2005 and (2) products manufactured prior to that date, and on or after October 23, 2003, must meet either the standards listed in this table or the applicable standards in subpart E of this part for a "commercial packaged boiler."
*** For oil-fired storage water heaters: (1) the standards are mandatory for equipment manufactured on and after October 9, 2015 and (2) equipment manufactured prior to that date must meet a minimum thermal efficiency level of 78 percent.
† Water heaters and hot water supply boilers having more than 140 gallons of storage capacity need not meet the standby loss requirement if: (1) the tank surface area is thermally insulated to R-12.5 or more, (2) a standing pilot light is not used, and (3) for gas or oil-fired storage water heaters, they have a fire damper or fan-assisted combustion.
‡ Energy conservation standards for electric instantaneous water heaters are included in EPCA. (42 U.S.C. 6313(a)(5)(D)-(E)) The compliance date for these energy conservation standards is January 1, 1994. In this final rule, DOE codifies these standards for electric instantaneous water heaters in its regulations at 10 CFR 431.110. Further discussion of standards for electric instantaneous water heaters is included in section III.B.3 of this final rule.

Table II.2 Current Energy Conservation Standards for Residential-Duty Commercial Water Heaters

Equipment	Specification*	Draw Pattern**	Uniform Energy Factor	Compliance Date
Gas-fired Storage	>75 kBtu/h and ≤105 kBtu/h and ≤120 gal	Very Small	$0.2674 - (0.0009 \times V_r)$	December 29, 2016
		Low	$0.5362 - (0.0012 \times V_r)$	
		Medium	$0.6002 - (0.0011 \times V_r)$	
		High	$0.6597 - (0.0009 \times V_r)$	
Oil-fired storage	>105 kBtu/h and ≤140 kBtu/h and ≤120 gal	Very Small	$0.2932 - (0.0015 \times V_r)$	
		Low	$0.5596 - (0.0018 \times V_r)$	
		Medium	$0.6194 - (0.0016 \times V_r)$	
		High	$0.6740 - (0.0013 \times V_r)$	
	>12 kW and	Very Small	0.80	

Equipment	Specification*	Draw Pattern**	Uniform Energy Factor	Compliance Date
Electric instantaneous	≤58.6 kW and ≤2 gal	Low	0.80	
		Medium	0.80	
		High	0.80	

* Additionally, to be classified as a residential-duty water heater, a commercial water heater must meet the following conditions: (1) if requiring electricity, use single-phase external power supply; and (2) the water heater must not be designed to heat water at temperatures greater than 180 °F.
** Draw pattern is a classification of hot water use of a consumer water heater or residential-duty commercial water heater, based upon the first-hour rating. The draw pattern is determined using the *Uniform Test Method for Measuring the Energy Consumption of Water Heaters* in appendix E to subpart B of 10 CFR part 430.

2. History of Standards Rulemaking for CWH Equipment

As previously noted, EPCA established initial Federal energy conservation standards for CWH equipment that generally corresponded to the levels in ASHRAE Standard 90.1-1989. On October 29, 1999, ASHRAE released Standard 90.1-1999, which included new efficiency levels for numerous categories of CWH equipment. DOE evaluated these new standards and subsequently amended energy conservation standards for CWH equipment in a final rule published in the *Federal Register* on January 12, 2001. 66 FR 3336 ("January 2001 final rule"). DOE adopted the levels in ASHRAE Standard 90.1-1999 for all classes of CWH equipment, except for electric storage water heaters. For electric storage water heaters, the standard in ASHRAE Standard 90.1-1999 was less stringent than the standard prescribed in EPCA and, consequently, would have increased energy consumption.

Under those circumstances, DOE could not adopt the new efficiency level for electric storage water heaters in ASHRAE Standard 90.1-1999. 66 FR 3336, 3350. In the January 2001 final rule, DOE also adopted the efficiency levels contained in the Addendum to ASHRAE Standard 90.1-1989 for hot water supply boilers, which were identical to the efficiency levels for instantaneous water heaters. 66 FR 3336, 3356.

On October 21, 2004, DOE published a direct final rule in the *Federal Register* ("October 2004 direct final rule") that recodified the existing energy conservation standards, so that they are located contiguous with the test procedures that were promulgated in the same notice. 69 FR 61974. The October 2004 final rule also updated definitions for CWH equipment at 10 CFR 431.102.

The American Energy Manufacturing Technical Corrections Act ("AEMTCA"), Pub. L. 112-210 (Dec. 18, 2012), amended EPCA to require that DOE publish a final rule establishing a uniform efficiency descriptor and accompanying test methods for covered consumer water heaters and some CWH equipment. (42 U.S.C. 6295(e)(5)(B)) EPCA further required that the final rule must replace the energy factor (for consumer water heaters) and thermal efficiency and standby loss (for some commercial water heaters) metrics with a uniform efficiency descriptor. (42 U.S.C. 6295(e)(5)(C)) Pursuant to 42 U.S.C. 6295(e), on July 11, 2014, DOE published a final rule for test procedures for residential and certain commercial water heaters ("July 2014 final rule") that, among other things, established UEF, a revised version of the current residential energy factor metric, as the uniform efficiency descriptor required by AEMTCA. 79 FR 40542, 40578. In addition, the July 2014 final rule defined the term "residential-duty commercial water heater," an equipment category that is subject to the new UEF metric and the corresponding UEF test procedures. 79 FR 40542, 40586–40588 (July 11, 2014). Conversely, CWH equipment that does not meet the definition of a residential-duty commercial water heater is not subject to the UEF metric or corresponding UEF test procedures. *Id.* Further details on the UEF metric and residential-duty commercial water heaters are discussed in section III.C of this document.

In a notice of proposed rulemaking ("NOPR") published on April 14, 2015 ("April 2015 NOPR"), DOE proposed, among other things, conversion factors from thermal efficiency and standby loss to UEF for residential-duty commercial water heaters. 80 FR 20116, 20143. Subsequently, in a final rule published on December 29, 2016 (the "December 2016 conversion factor final rule"), DOE specified standards for residential-duty commercial water heaters in terms of UEF. However, while the metric was changed from thermal efficiency and/or standby loss, the stringency was not changed. 81 FR 96204, 96239 (Dec. 29, 2016).

In ASHRAE Standard 90.1-2013, ASHRAE increased the thermal efficiency level for commercial oil-fired storage water heaters, thereby triggering DOE's statutory obligation to promulgate an amended uniform national standard at those levels, unless DOE were to determine that there is clear and convincing evidence supporting the adoption of more-stringent energy conservation standards than the ASHRAE levels.[15] In a final rule published on July 17, 2015 ("July 2015 ASHRAE equipment final rule"), among other things, DOE adopted the standard for commercial oil-fired storage water heaters at the level set forth in ASHRAE Standard 90.1-2013, which increased the standard from 78 to 80 percent thermal efficiency with compliance required starting on October 9, 2015. 80 FR 42614 (July 17, 2015). Since that time ASHRAE has issued 2

[15] ASHRAE Standard 90.1-2013 also appeared to change the standby loss levels for four equipment classes (gas-fired storage water heaters, oil-fired storage water heaters, gas-fired instantaneous water heaters, and oil-fired instantaneous water heaters) to efficiency levels that surpassed the Federal energy conservation standard levels. However, upon reviewing the changes DOE concluded that all changes to standby loss levels for these equipment classes were editorial errors because they were identical to SI (International System of Units; metric system) formulas rather than I-P (Inch-Pound; English system) formulas. As a result, DOE did not conduct an analysis of the potential energy savings from amended standby loss standards for this equipment in response to the ASHRAE updates. DOE did not receive any comments on this issue. 80 FR 1171, 1185 (January 8, 2015). The standby loss levels for these equipment classes were reverted to the previous levels in ASHRAE Standard 90.1-2016 and have not been updated since then.

updated versions of Standard 90.1, 90.1-2016 and 90.1-2019. However, DOE was not triggered to review amended standards for commercial water heaters by any updates in ASHRAE Standard 90.1-2016 or ASHRAE Standard 90.1-2019. Overall, DOE has not been triggered to review the standards for the equipment subject to this rulemaking (*i.e.*, commercial water heating equipment other than commercial oil-fired storage water heaters) based on an update to the efficiency levels in ASHRAE Standard 90.1 since the 1999 edition because ASHRAE has not updated the efficiency levels for such equipment since 1999.

On October 21, 2014, DOE published a request for information ("RFI") as an initial step for reviewing the energy conservation standards for CWH equipment. 79 FR 62899 ("October 2014 RFI"). The October 2014 RFI solicited information from the public to help DOE determine whether more-stringent energy conservation standards for CWH equipment would result in a significant amount of additional energy savings, and whether those standards would be technologically feasible and economically justified. 79 FR 62899, 62899–62900. DOE received a number of comments from interested parties in response to the October 2014 RFI.

On May 31, 2016, DOE published a NOPR and notice of public meeting in the *Federal Register* ("May 2016 CWH ECS NOPR") that addressed all of the comments received in response to the RFI and proposed amended energy conservation standards for CWH equipment. 81 FR 34440. The May 2016 CWH ECS NOPR and the technical support document ("TSD") for that NOPR are available at *www.regulations.gov/docket?D=EERE-2014-BT-STD-0042*.

On June 6, 2016, DOE held a public meeting at which it presented and discussed the analyses conducted as part of this rulemaking (*e.g.,* engineering analysis, LCC, PBP, and MIA). In the public meeting, DOE presented the results of the analysis and requested comments from stakeholders on various issues related to the rulemaking in response to the May 2016 CWH ECS NOPR.

On December 23, 2016, DOE published a notice of data availability ("NODA") for energy conservation standards for CWH equipment ("December 2016 CWH ECS NODA"). 81 FR 94234. The December 2016 CWH ECS NODA presented the thermal efficiency and standby loss levels analyzed in the May 2016 CWH ECS NOPR for residential-duty gas-fired storage water heaters in terms of UEF, using the updated conversion factors for gas-fired and oil-fired storage water heaters adopted in the December 2016 conversion factor final rule (81 FR 94234, 94237).

On January 15, 2021, in response to a petition for rulemaking submitted by the American Public Gas Association, Spire, Inc., the Natural Gas Supply Association, the American Gas Association, and the National Propane Gas Association (83 FR 54883; Nov. 1, 2018) DOE published a final interpretive rule ("the January 2021 final interpretive rule") determining that, in the context of residential furnaces, commercial water heaters, and similarly-situated products/equipment, use of non-condensing technology (and associated venting) constitute a performance-related "feature" under EPCA that cannot be eliminated through adoption of an energy conservation standard. 86 FR 4776. Correspondingly, DOE withdrew the May 2016 CWH ECS NOPR.[16] 86 FR

[16] The rulemaking for CWH equipment has been subject to multiple rounds of public comment, including public meetings, and extensive records have been developed in the relevant dockets. (*See* Docket Number EERE-2014-BT-STD-0042). Consequently, although the May 2016 CWH ECS NOPR was withdrawn, the

3873 (Jan. 15, 2021). However, DOE has subsequently published a final interpretive rule that returns to the previous and long-standing interpretation (in effect prior to the January 15, 2021 final interpretive rule), under which the technology 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 (Dec. 29, 2021). In conducting the analysis for this final rule, DOE evaluates condensing technologies and associated venting systems (*i.e.*, trial standard levels ("TSLs") 2, 3, and 4) in its analysis of potential energy conservation standards. Any adverse impacts on utility and availability of non-condensing technology options are considered in DOE's analyses of these TSLs.

On May 19, 2022, DOE published a NOPR ("May 2022 CWH ECS NOPR") for CWH equipment, in which DOE proposed amended energy conservation standards for certain classes of CWH equipment and proposed to codify existing standards from EPCA for commercial electric instantaneous water heaters (except for residential-duty commercial electric instantaneous water heaters).[17] 87 FR 30610. DOE received 28 comments in response to the May 2022 CWH ECS NOPR from the interested parties listed in Table II.3.

Table II.3 May 2022 CWH ECS NOPR Written Comments

Commenter(s)	Abbreviation	Comment No. in the Docket	Commenter Type*
Sean Erwin	Sean Erwin	6	I
The American Gas Association ("AGA"), American Public Gas Association ("AGPA"), National Propane Gas	Joint Gas Commenters	7, 14, 34	UA

information obtained through those earlier rounds of public comment, information exchange, and data gathering have been considered in this rulemaking.

[17] On July 20, 2022, DOE published a notice that re-opened the comment period for the May 2022 CWH ECS NOPR to allow comments to be submitted until August 1, 2022. 87 FR 43226.

Commenter(s)	Abbreviation	Comment No. in the Docket	Commenter Type*
Association ("NPGA"), Spire Inc., and ONE Gas, Inc.			
JJM Alkaline Technologies	JJM Alkaline	10	M
Atmos Energy Corporation	Atmos Energy	11, 36	U
American Public Gas Association	APGA	13**	UA
Bradford White Corporation	Bradford White	12, 23	M
Law Offices of Barton Day, PLLC (representing Spire)	Barton Day Law	13**	U
American Society for Testing and Materials	ASTM	15	EA
Suburban Propane Partners, L.P.	Suburban Propane	16	U
Center for Climate and Energy Solutions, Institute for Policy Integrity at New York University School of Law, Montana Environmental Information Center, Natural Resources Defense Council, Sierra Club, Union of Concerned Scientists	Joint Climate Commenters	19	EA
Bock Water Heaters, Inc.	Bock Water Heaters	20	M
Northwest Power and Conservation Council	NWPCC	21	EA
A.O. Smith Corporation	A.O. Smith	22	M
Rheem Manufacturing Company	Rheem	24	M
WM Technologies, LLC	WM Technologies	25	M
Patterson-Kelley, LLC	Patterson-Kelley	26	M
California Energy Commission	CEC	27	EA
Plumbing-Heating-Cooling Contractors National Association	PHCC	28	TA
Appliance Standards Awareness Project (ASAP), American Council for an Energy-Efficient Economy (ACEEE), Natural Resources Defense Council (NRDC), and Rocky Mountain Institute (RMI)	Joint Advocates	29	EA
New York State Energy Research and Development Authority	NYSERDA	30	EA
Air-Conditioning, Heating, and Refrigeration Institute	AHRI	31	TA
The Aluminum Association; American Coke and Coal Chemicals Institute; American	The Associations	32	TA

Commenter(s)	Abbreviation	Comment No. in the Docket	Commenter Type*
Farm Bureau Federation; American Gas Association; American Public Gas Association; Council of Industrial Boiler Owners; Independent Petroleum Association of America; National Mining Association; U.S. Chamber of Commerce			
California Investor-Owned Utilities (Pacific Gas and Electric Company (PG&E), San Diego Gas and Electric (SDG&E), and the Southern California Edison (SCE))	CA IOUs	33, 37	UA
Northwest Energy Efficiency Alliance	NEEA	35	EA

*TA: trade association, EA: efficiency/environmental advocate, IR: industry representative, M: manufacturer, OS: other stakeholder, U: utility, utilities filing jointly, or utility representative, UA: utility association, and I: individual.
** Comments raised during the June 23, 2022 public meeting. Docket No. 13 refers to the public meeting transcript.

A parenthetical reference at the end of a comment quotation or paraphrase provides the location of the item in the public record.[18] To the extent that interested parties have provided written comments that are substantively consistent with any oral comments provided during the June 23, 2022 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.

C. Deviation from Appendix A

On June 21, 2023, DOE published a test procedure final rule for consumer water heaters and residential-duty commercial water heaters. 88 FR 40406. In accordance with

[18] The parenthetical reference provides a reference for information located in the docket of DOE's rulemaking to develop energy conservation standards for CWH equipment. (Docket No. EERE-2021-BT-STD-0027, which is maintained at *www.regulations.gov*). The references are arranged as follows: (commenter name, comment docket ID number, page of that document).

section 3(a) of 10 CFR part 430, subpart C, appendix A ("appendix A"), DOE notes that it is deviating from the provision in appendix A specifying that test procedures be finalized at least 180 days before new or amended standards are proposed for the same equipment. 10 CFR part 430, subpart C, appendix A, section 8(d)(2). DOE is opting to deviate from this step because the DOE has determined that the test procedure amendments for residential-duty commercial water heaters will not impact the current efficiency ratings. 88 FR 40406, 40412. See section III.C of this document for additional information on the test procedures for CWH equipment.

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. Clear and Convincing Threshold

In response to the May 2022 CWH ECS NOPR in which DOE concluded that it had clear and convincing evidence to propose a standard more stringent than ASHRAE Standard 90.1, the Joint Gas Commenters stated that since CWH are included in ASHRAE Standard 90.1, DOE must presume that standards more stringent than the ASHRAE standards would not be desirable in the absence of clear and convincing evidence that they are justified. Therefore, the commenters argued that DOE must resolve doubts against the need for more stringent standards, but in developing the

NOPR, the Joint Gas Commenters stated that DOE has done the opposite. (Joint Gas Commenters, No. 34 at pp. 15–16) The Joint Gas Commenters stated that DOE should follow the rulings of ASHRAE 90.1, and noted that to date, the ASHRAE committee has not considered an increase in the energy efficiency of these commercial water heaters in order to lower overall energy consumption. (Joint Gas Commenters, No. 34 at p. 34)

Contrary to the Joint Gas Commenters' suggestion, EPCA does not require DOE to presume that standards more stringent than the ASHRAE standards would not be desirable in the absence of clear and convincing evidence that they are justified. As noted by the Joint Gas Commenters and as discussed in section II.A of this final rule, pursuant to EPCA, DOE must determine, supported by clear and convincing evidence, that amended standards for CWH equipment would result in significant additional conservation of energy and be technologically feasible and economically justified. (42 U.S.C. 6313(a)(6)(A)(ii)(II); 42 U.S.C. 6313(a)(6)(C)(i)) In making the determination of economic justification of an amended standard, DOE must determine whether the benefits of the proposed standard exceed the burdens of the proposed standard by considering, to the maximum extent practicable, the seven criteria described in EPCA (see 42 U.S.C. 6313(a)(6)(B)(ii)(I)-(VII)). The clear and convincing threshold is a heightened standard, and would only be met where the Secretary has an abiding conviction, based on available facts, data, and DOE's own analyses, that it is highly probable an amended standard would result in a significant additional amount of energy savings, and is technologically feasible and economically justified. *See American Public Gas Association v. U.S. Dept of Energy*, 22 F.4th at 1025 (D.C. Cir. January 18, 2022) (citing *Colorado v. New Mexico*, 467 U.S. 310, 316, 104 S.Ct. 2433, 81 L.Ed.2d 247

(1984)). However, this standard does not require a presumption of desirability for the efficiency levels in ASHRAE 90.1. As noted previously, DOE has determined that there is clear and convincing evidence for standards for CWH equipment more stringent than those found in ASHARE 90.1. A discussion of DOE's consideration of the statutory factors is contained in section V of this final rule.

2. Analytical Structure and Inputs

In response to both the withdrawn May 2016 CWH ECS NOPR and the May 2022 CWH ECS NOPR, DOE received comments and information regarding the assumptions that it used for inputs in the rulemaking analyses. DOE considered these comments in appropriate analyses conducted in this final rule and modified its assumptions and inputs as necessary to account for the information or feedback provided by industry representatives. Section IV of this final rule provides details on DOE's updates to its various analyses.

Addressing the specific analysis that supports this rulemaking, Bradford White highlighted that some sources are as many as 14 years old and urged DOE to conduct updated surveys and studies in order to inform these major regulatory policy decisions. (Bradford White, No. 23 at p. 7) Additionally, the Joint Gas Commenters stated that in several cases, DOE lacks the data required to provide or support critical inputs to its analysis. (The Joint Gas Commenters, No. 34 at p. 16) In response, DOE uses the most recent data sources available at the time of the analysis whenever possible, as discussed further throughout section IV of this document.

The Joint Gas Commenters urged DOE to implement recommendations from the recent National Academies of Sciences, Engineering, and Medicine ("NASEM") report into all its appliance rulemakings, highlighting recommendations 2-2, 3-5, 4-1, 4-13, and 4-14 as the most pertinent. (Joint Gas Commenters, No. 34 at pp. 38–39) In response, the Department notes that the rulemaking process for standards of covered products and equipment are outlined at appendix A to subpart C of 10 CFR part 430 ("appendix A"), 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.

PHCC noted that this rule impacts the resources of PHCC; therefore, PHCC feels it is necessary to present the contractors' perspective on these issues. PHCC stated that certain customers would bear extraordinary costs as a result of this rule, and claimed that PHCC's members will ultimately be the ones to shoulder the effects to those consumers by finding economical solutions for their clients. (PHCC, No. 28 at p. 11) In response, DOE recognizes that contractors play an important role in helping consumers purchase and install CWH equipment. DOE appreciates the perspective of all interested parties, including contractors and realizes that contractors will likely be responsible for characterizing the costs for new and replacement equipment installations to their customers as well as assisting in identifying and implementing economical solutions. DOE's evaluation of the cost and benefits of this final rule is discussed in section V of this document, including impacts on certain consumers.

3. Final Selection of Standards Levels

DOE received several comments expressing general approval or disapproval for the proposed standards.

The Joint Advocates, NYSERDA, the CA IOUs, and CEC supported the proposed standards. (Joint Advocates, No. 29 at p. 1; NYSERDA No. 30 at p. 2; CEC, No. 27 at p. 1; CA IOUs, No. 33 at p. 1) NYSERDA stated that DOE should act swiftly to finalize the proposed standards and noted that these standards will play an important role in meeting their state climate goals through decarbonization of the water heater market. (NYSERDA, No. 30 at pp. 1–2)

The CA IOUs expressed general support for DOE's proposal to increase the efficiency requirements of commercial gas water heaters to condensing levels and suggested that market data show that the market is ready for this increase. (CA IOUs, No. 33 at p. 1) NEEA also stated support for DOE's proposal to increase the efficiency levels of CWH equipment to reflect condensing performance, and asserted that they find the DOE analysis to be sound. They similarly commented in support of DOE's proposal to increase the efficiency requirements of gas-fired residential-duty commercial storage products. They explained that doing so will realize the energy efficiency goals that were intended with the residential standard, and would harmonize commercial and residential requirements. (NEEA, No. 35 at p. 1)

The Joint Advocates echoed similar support for the proposed standards and mentioned that updated standards for commercial gas-fired water heaters are long overdue as they have not been amended since 2001. (The Joint Advocates, No. 29 at p. 1)

The CEC stated that based on data from its Modernized Appliance Efficiency Database System ("MAEDbS"), CWH products meeting the proposed standard are already certified for sale in California; 50 percent (969 out of 1936) meet the proposed requirement of 95 percent thermal efficiency and 24 percent (299 out of 1259) of the instantaneous models meet the proposed 96 percent thermal efficiency. The CEC argues that these data indicate no market barrier to the proposed standards. (CEC, No. 27 at p. 4) The CEC also encouraged DOE to finalize its proposal to phase out non-condensing technology, thus closing what they consider a significant loophole for standards of residential-duty CWHs. *Id*. at p. 3. Further, according to CEC, MAEDbS includes 324 residential-duty commercial gas water heaters, and none have storage above 55 gallons. Therefore, CEC claims that residential water heaters in California's market are exploiting this "loophole" since consumer gas ratings with input ratings above 75,000 Btu/hour would only be subject to a condensing standard if the storage volume is greater than 55 gallons. *Id*. The CA IOUs supported DOE's proposed standards, and raised the same concern as CEC, stating that the energy efficiency standards for residential gas storage water heaters with a capacity greater than 55 gallons are currently higher than the requirements for commercial residential-duty gas storage heaters of similar capacity. As a result, they claim that the greater-than-55-gallon-capacity segment of the residential gas storage water heater market is exclusively served by commercial residential-duty products. (CA IOUs, No. 33 at p. 2) Rheem also suggested that DOE evaluate the proposed efficiency levels for residential-duty commercial gas-fired storage water heaters to ensure more equitable treatment for these products and consumer water heaters with a rated storage volume greater than 55 gallons because, they said, these categories can be used for the same applications. (Rheem, No. 24 at pp. 3–4)

Sean Erwin commented that DOE's proposal is agreeable, but also explained various types of solar water heating systems that could be a cost-effective means of generating hot water. (Erwin, No. 6 at p. 1)

A.O. Smith also commented noting support for DOE's proposal to move the minimum energy conservation standards for CWH to a standard that will require the utilization of condensing technology for gas-fired equipment, inclusive of both the proposed thermal efficiency and standby loss levels, with some modifications. (A.O. Smith, No. 22 at pp. 2, 7) A.O. Smith commented that that the adoption of this equipment will not only assist in reducing greenhouse gas emissions, but will also help property and business owners save money on their monthly energy bills, as well as preserve flexibility for businesses to install water heating equipment that is the most economical to meet the intended utility. A.O. Smith also recommended that high-efficiency gas-fired water heating equipment remain available for commercial customers. *Id*. at pp. 2–3. A.O. Smith suggested several modifications to the standards proposed in the May 2022 CWH ECS NOPR, which are discussed in the appropriate sections on this final rule. *Id*. at pp. 2–5. Additionally, Rheem raised concerns that many equipment sizes are not available at the proposed thermal efficiency levels and that, in some cases, the proposed levels are at the maximum technologically feasible ("max-tech") levels evaluated. Rheem also stated that the DOE's analysis has not shown that the proposed TSL is economically viable for the entire range of equipment sizes. (Rheem, No. 24 at p. 2)

Several commenters suggested that DOE should analyze a 94 percent thermal efficiency level for gas-fired water heaters (A.O. Smith, No. 22 at pp. 2-4; AHRI, No. 31

at p. 2; Rheem, No. 24 at p. 3). These comments, and DOE's response, are discussed in more detail in section IV.C.4.a of this document. A.O. Smith also proposed an adjustment to the proposed efficiency level for gas-fired residential-duty commercial water heaters, as discussed in section IV.C.4.c of this document.

AHRI raised concerns that, because gas-fired storage and gas-fired instantaneous equipment are used in similar settings, setting higher efficiency standards for one class (*i.e.*, gas-fired instantaneous water heaters and hot water supply boilers) inappropriately disadvantages that class in the marketplace compared to the other class(es). Therefore, AHRI requested the Department align the efficiency standards for all gas-fired water heaters. (AHRI, No. 31 at p. 2). Bock Water Heaters asserted their agreement with comments submitted by AHRI. (Bock Water Heaters, No. 20 at p. 2) DOE received a similar comment from Bradford White expressing concern that DOE has proposed more stringent requirements for gas-fired instantaneous water heaters, including hot water supply boilers, for greater than 10 gallons. Bradford White recommended that the thermal efficiency requirements for gas-fired instantaneous and hot water supply boilers be harmonized with that for gas-fired storage water heaters. They further noted that this approach would allow DOE to avoid unfairly biasing the marketplace towards one technology over another. (Bradford White, No. 23 at p. 3)

The Joint Gas Commenters argued that a condensing standard would have numerous adverse impacts on building owners, including required building modifications, impacts on other equipment, impacts on occupied spaces or building aesthetics, inconvenience or loss to business as a result of additional time spent replacing equipment, additional installation services, or overall impracticality. (Joint Gas

Commenters, No. 34 at pp. 9–10) They added that the proposed standards would violate the "unavailability" provision of EPCA and would leave many purchasers without gas products suitable for their needs. (Joint Gas Commenters, No. 34 at p. 39) WM Technologies called on DOE to rigorously review the inputs and the calculations in the LCC analysis because, they suggest, under the anti-backsliding provision of EPCA, the damage to the end user would be irreparable should the Department promulgate condensing requirements for commercial water heaters. WM Technologies asserted that such requirements would exceed the existing infrastructures' ability to adapt to condensing products and appliances in many places across the country, resulting in the unavailability of the product due to an increase in the minimum efficiency, violating the unavailability clause of EPCA (EPACT). As an example, WM Technologies stated that row houses in many urban East Coast regions do not have the ability to vent through an outside wall, which is a requirement for many condensing products. (WM Technologies, No. 25 at pp. 5–6) Atmos Energy stated that DOE should allow the continued manufacture and availability of water heaters that meet consumer needs (including businesses) and suggested that the elimination of affordable products would undermine the goals of the energy efficiency program overall. (Atmos Energy, No. 36 at pp. 1–2) DOE has provided more specific responses to these comments throughout this document, but specifically, DOE addresses comments regarding the downtime during replacement in section IV.F.2.h of this document, comments regarding the unavailability of noncondensing commercial water heaters in section IV.A.2.b of this document and comments regarding the unavailability of certain equipment sizes in IV.C.4.a of this document. Because there are comments relating to regional differences, DOE would note that the analysis accounts for the impact of entering water temperature on loads by type of building, both of which are linked to region by the location variables included in the source databases (see section IV.E of this document). However, DOE would specifically note that row houses tend to be comprised of single family dwellings that DOE believes are far more likely to use consumer water heaters or potentially a consumer boiler with unfired storage tanks rather than the CWH equipment that is the subject of this final rule.

Atmos Energy stated that where insufficient data exist, DOE should conclude it lacks evidence to support its proposed rule. It further offered its opinion that more data are needed to assess the proposed rule, including distributions of equipment by storage volume and input capacities, frequencies of installations that are infeasible or costly, installed costs, and customers' annual fuel use. Atmos Energy stated that real-world data exist for this information and stated that DOE should collect actual data rather than relying on estimates, though Atmos Energy does not provide any such data or suggested sources. To ensure standards are economically justified, Atmos Energy stated DOE must fully assess LCC, potential for fuel switching, economic benefits of efficiency improvements, and actual installation costs. (Atmos Energy, No. 36 at pp. 2, 4)

As already noted, DOE uses the most current data available when performing rulemaking analyses, such as this CWH analysis. Atmos Energy is correct in the assertion that considerable data exist, but overlooks the fact that much of these data exists in forms not in the public domain. For example, consumers receive quotes for installing new or replacement water heaters, but such information is proprietary to the parties involved, and even if not proprietary, DOE is unaware of any existing service or process that aggregates such information. Contrary to the position Atmos Energy takes the fact that this information may exist in some form does not make this information necessarily available or usable to the general public or to DOE. Some of the data that Atmos Energy claims DOE should collect and use are not reasonably available to DOE. DOE uses publicly available and referenceable cost data, along with information collected during manufacturer interviews, to develop models to estimate such information in a fashion reasonably consistent with installation practice. For example, DOE uses U.S. Census data for developing contractor markup for installation costs; manufacturer shipment, DOE's Compliance Certification Management System, and Energy Star data to develop equipment efficiency distributions; and price data from RSMeans and/or from available and referenceable public sources. In short, DOE's method is to collect and use the best current data that are available to DOE and to develop analyses to estimate in a reasonable fashion the costs and benefits of proposed energy conservation standards. The specific analyses listed by Atmos Energy are addressed within this final rule document.

As a general response to the comments in this section, DOE notes that it may prescribe an energy conservation standard more stringent than the level for such equipment in ASHRAE Standard 90.1, as amended, only if "clear and convincing evidence" shows that a more-stringent standard would result in significant additional conservation of energy and is technologically feasible and economically justified. (42 U.S.C. 6313(a)(6)(A)(ii)(II)) 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. 6313(a)(6)(B)(ii)(I)-(VII) and 42 U.S.C. 6313(a)(6)(C)(i)) As described in section V.A of this document, DOE typically evaluates potential amended standards for products and equipment by grouping individual efficiency levels for each class into TSLs. The use of TSLs allows DOE to identify and consider, among other things, market cross elasticity from consumer purchasing decisions that may change when different standard levels are set. DOE typically evaluates potential amended standards for products and equipment by grouping individual efficiency levels for each class into TSLs. Furthermore, as described in section V.C of this document, DOE considered the impacts of amended standards for CWH equipment at each TSL, with respect to the aforementioned criteria, and determined that there is clear and convincing evidence that the adopted standards are both technologically feasible and economically justified and save a significant amount of energy. The benefits and costs of the standard levels adopted in this final rule are discussed in section V.C.2 of this document.

B. Scope of Coverage

1. Oil-Fired Commercial Water Heating Equipment

As discussed in the May 2022 CWH ECS NOPR, DOE has determined that amended efficiency standards (in terms of both thermal efficiency and standby loss) for commercial oil-fired storage water heaters (including residential-duty oil-fired storage water heaters) would not be warranted and did not analyze amended efficiency standards for this equipment in this final rule. 87 FR 30610, 30622.

Similarly, DOE did not analyze amended standards for commercial oil-fired instantaneous water heaters and hot water supply boilers in the May 2022 CWH ECS NOPR because the energy savings possible from amended standards for such equipment is expected to be negligible. *Id.* Based on this rationale and because DOE has not received information suggesting otherwise, DOE has continued to exclude commercial oil-fired water heating equipment from the analysis conducted for this final rule.

2. Unfired Hot Water Storage Tanks

Unfired hot water storage tanks are a class of CWH equipment. In response to the May 2022 CWH ECS NOPR, the CA IOUs stated that the efficiency requirements for unfired hot water storage tanks have been unrevised since 2001 and recommended that DOE develop performance requirements for unfired hot water storage tanks, which they said are often incorporated into heat pump water heating systems. (The CA IOUs, No. 33 at pp. 3–4) The CA IOUs requested that DOE develop performance-based testing and standards for unfired hot water storage tanks, stating that a performance-based metric would allow for innovation and would reward manufacturers who insulate well. *Id.*

On May 24, 2022, DOE published a notice of final determination not to amend energy conservation standards for unfired hot water storage tanks. 87 FR 31359. Because amended energy conservation standards for unfired hot water storage tanks were considered as part of that proceeding, they were not considered further for this final rule. Similarly, amended test procedures for unfired hot water storage tanks and other CWH equipment will be considered in a separate rulemaking.

3. Electric Instantaneous Water Heaters

EPCA prescribes energy conservation standards for several classes of CWH equipment manufactured on or after January 1, 1994. (42 U.S.C. 6313(a)(5)) DOE codified these standards in its regulations for CWH equipment at 10 CFR 431.110. However, when codifying these standards from EPCA, DOE inadvertently omitted the standards put in place by EPCA for electric instantaneous water heaters. Specifically, for instantaneous water heaters with a storage volume of less than 10 gallons, EPCA prescribes a minimum thermal efficiency of 80 percent. For instantaneous water heaters with a storage volume of 10 gallons or more, EPCA prescribes a minimum thermal efficiency of 77 percent and a maximum standby loss, in percent/hour, of 2.30 + (67/measured volume (in gallons)). (42 U.S.C. 6313(a)(5)(D) and (E)) Although, DOE's regulations at 10 CFR 431.110 do not currently include energy conservation standards for electric instantaneous water heaters, these standards prescribed in EPCA are applicable. Therefore, in this final rule, DOE is codifying these standards in its regulations at 10 CFR 431.110.

In the May 2022 CWH ECS NOPR, DOE also discussed allowing the use of a calculation-based method for determining storage volume of electric instantaneous water heaters that is the same as the method for gas-fired and oil-fired instantaneous water heaters and hot water supply boilers found at 10 CFR 429.72(e) (added at 81 FR 79261, 79320 (Nov. 10, 2016)). DOE initially concluded that the same rationale for including these provisions for gas-fired and oil-fired instantaneous water heaters and hot water supply boilers also applies to electric instantaneous water heaters (*i.e.*, it may be difficult to completely empty the instantaneous water heater in order to obtain a dry weight measurement, which is needed in a weight-based test for an accurate representation of the storage volume). Therefore, DOE tentatively concluded that including electric instantaneous water heaters in these provisions would provide manufacturers with flexibility as to how the storage volume is determined. 87 FR 30622. However, DOE is considering these certification changes in a separate rulemaking. Therefore, DOE is not enacting any changes at 10 CFR 429.72(e) to allow the use of a calculation-based method for determining the storage volume of electric instantaneous water heaters in this final rule.

Additionally, as discussed in the May 2022 CWH ECS NOPR, DOE notes that because electric instantaneous water heaters typically use electric resistance heating, which is highly efficient, the thermal efficiency of these units already approaches 100 percent. DOE has also determined that there are no options for substantially increasing the rated thermal efficiency of this equipment, and the impact of setting thermal efficiency energy conservation standards for these products would be negligible. Similarly, the stored water volume is typically low, resulting in limited potential for reducing standby losses for most electric instantaneous water heaters. As a result, amending the standards for electric instantaneous water heaters established in EPCA would result in minimal energy savings. Even if DOE were to account for the energy savings potential of amended standards for electric instantaneous water heaters, the contribution of any potential energy savings from amended standards for these units would be negligible and not appreciably impact the energy savings analysis for CWH equipment. Therefore, DOE did not analyze amended energy conservation standards for electric instantaneous water heaters in this final rule.[19]

[19] In the May 2022 CWH ECS NOPR, DOE noted that it did not analyze amended energy conservation standards for residential-duty electric instantaneous water heaters (87 FR 30631), which are a separate equipment class within DOE's regulations for CWH equipment. *See* 79 FR 40541, 40588 (Jul. 11, 2014). Consistent with the May 2022 CWH ECS NOPR, DOE did not analyze amended standards for residential-duty electric instantaneous water heaters in this final rule for similar reasons as those stated for not analyzing standards for electric instantaneous water heaters.

4. Commercial Heat Pump Water Heaters

In response to the May 2022 CWH ECS NOPR, DOE received multiple comments regarding DOE's proposal not to consider energy conservation standards for commercial heat pump water heaters. Rheem supported DOE's decision not to consider heat pump technology in the current analysis but encouraged DOE to review and amend the equipment class structure to include heat pump water heaters as a technology option for specific applications in a future rulemaking. (Rheem, No. 24 at p. 5) In contrast, NEEA and the CA IOUs requested that DOE include heat pump water heaters in its analysis. Both NEEA and the CA IOUs mentioned that these technologies represent the current max-tech efficiency levels for CWH. (NEEA, No. 35 at p. 2; the CA IOUs, No. 33 at p. 3) NEEA also stated that an analysis of current commercial water heating is incomplete without this consideration. (NEEA, No. 35 at p. 2) Further, NEEA, the CA IOUs, and the Joint Advocates noted that many commercial-duty heat pump products from several different manufacturers are available on the market already, and NEEA and the CA IOUs provided numerous citations to specific models. (NEEA, No. 35 at p. 2; the CA IOUs, No. 33 at p. 3; Joint Advocates, No. 29 at p. 14) The CA IOUs further commented that commercial electric heat pump water heaters have already been successfully and efficiently providing hot water to commercial buildings across the country and can include electric resistance elements that allow them to deliver comparable peak demand performance to commercial electric-resistance-only storage water heaters. (CA IOUs, No. 33 at p. 3)

WM Technologies and Patterson-Kelley argued that they are not aware of compressor-based water heating products which can operate at the water temperatures required to achieve commercial hot water flow rate at adequate temperatures, let alone sanitizing conditions, and added that if such products become available, the sizing of various internal components would be significantly different than heat pumps utilized for other applications. (WM Technologies, No. 25 at p. 7; Patterson-Kelley, No. 26 at p. 5) WM Technologies and Patterson-Kelley also stated that if available, those products should be required to meet the efficiencies at operating conditions of adequate hot water flow rate at the required temperature. *Id.* Furthermore, WM Technologies said, if any part of the heat pump system is located in unconditioned spaces, that portion of the heat pump should be maintained at the worst-case national temperature at which the product may experience during efficiency testing. (WM Technologies, No. 25 at p. 7)

Rheem, AHRI, and Bradford White additionally suggested that it may be difficult to meet the same hot water loads with an integrated heat pump as with a commercial electric storage water heater. (AHRI, No. 31 at pp. 3–4; Rheem, No. 24 at p. 5; Bradford White, No. 23 at pp. 7–8) The commenters further noted that heat pump water heaters typically have a slower recovery time than commercial electric storage water heaters and may also have difficulty reaching the same temperatures as commercial electric storage water heaters without backup resistance elements. *Id*. Further, Rheem and AHRI noted in particular that integrated heat pump water heaters may have difficulty reaching sanitizing temperatures. (AHRI, No. 31 at pp. 3–4; Rheem, No. 24 at p. 5) Rheem also noted that the larger footprint may limit replacement opportunities and may result in a decrease in workspace (such as kitchen space) as opposed to a decrease in mechanical room space. (Rheem, No. 24 at p. 5) Furthermore, Bradford White stated that given that most heat pump water heaters recover at a much slower rate, additional storage capacity must be added to the hot water system, which likely means that a split system heat pump water heater would be used instead of an integrated heat pump water heater. (Bradford White, No. 23 at p. 7)

DOE did not consider commercial integrated heat pump water heaters in this final rule. DOE found only one such model on the market, at a single storage volume and heating capacity. Given the wide range of capacities and stored water volumes in products currently on the market, which are required to meet hot water loads in commercial buildings, it is unclear based on this single model whether heat pump water heater technology would be suitable to meet the range of load demands on the market. Similarly, based on the information currently available and comments regarding the performance of heat pump water heaters as compared to electric resistance water heaters in commercial settings, it is uncertain if split-system heat pump water heaters can serve all the applications currently filled by electric instantaneous water heaters. Therefore, DOE is not analyzing this equipment in the current analysis. However, DOE may analyze commercial heat pump water heaters in a future rulemaking, at which time DOE will consider the appropriate equipment class structure for commercial electric water heaters, including commercial heat pump water heaters.

5. Electric Storage Water Heaters

In this rulemaking, DOE did not analyze thermal efficiency standards for electric storage water heaters. Electric storage water heaters are not currently subject to a thermal efficiency standard under 10 CFR 431.110. Electric storage water heaters typically use electric resistance heating elements, which are highly efficient. The thermal efficiency of these units already approaches 100 percent. As discussed in section III.B.4 of this document, DOE did not consider commercial integrated heat pump water heaters as the max-tech for electric storage water heaters at this time.

In the May 2022 CWH ECS NOPR, DOE concluded that the only technology option that DOE analyzed in the engineering analysis as providing standby loss reduction for electric storage water heaters (*i.e.*, increasing tank foam insulation thickness to 3 inches) is already currently included in some models rated at or near the current standby loss standard. Consequently, DOE did not analyze any technology options for reducing standby loss below (*i.e.*, more stringent than) the current standard. In response to the May 2022 CWH ECS NOPR, Bock Water Heaters indicated support for not amending the standby loss standard for electric storage water heaters. (Bock Water Heaters, No. 20 at p. 1) Bradford White similarly supported DOE's decision not to change standards for commercial electric storage, as there is no electric resistance or insulation technology that would allow them to comply with more stringent standards. (Bradford White, No. 23 at p. 3) DOE maintains its conclusion originally stated in the May 2022 CWH ECS NOPR and therefore, in this final rule, DOE did not further analyze and is not adopting amended standby loss standards for electric storage water heaters.

6. Instantaneous Water Heaters and Hot Water Supply Boilers

Other than storage-type instantaneous water heaters, DOE did not include instantaneous water heaters and hot water supply boilers in its analysis of potential amended standby loss standards.[20] Instantaneous water heaters and hot water supply boilers (other than storage-type instantaneous water heaters) with greater than 10 gallons

[20] On November 10, 2016, DOE published a final rule amending the test procedures for certain CWH equipment ("November 2016 CWH TP final rule"). 81 FR 79261. DOE adopted a definition for "storage-type instantaneous water heater" in the November 2016 CWH TP final rule. *Id.* at 79289–79290. Storage-type instantaneous water heaters are discussed in section IV.A.2.a of this final rule.

of water stored have a standby loss requirement under 10 CFR 431.110. However, DOE did not analyze more stringent standby loss standards for these units because it has determined that such amended standards would result in minimal energy savings. Even if DOE were to account for the energy savings potential of amended standby loss standards for instantaneous water heaters and hot water supply boilers (other than storage-type instantaneous water heaters) with greater than 10 gallons of water stored CWH equipment, the contribution of any potential energy savings from amended standards for these units would be negligible and not appreciably impact the energy savings analysis for CWH equipment.

DOE has determined that instantaneous water heaters (other than storage-type instantaneous water heaters) and hot water supply boilers with less than 10 gallons of water stored would not have significantly different costs and benefits as compared to instantaneous water heaters (other than storage-type instantaneous water heaters) and hot water supply boilers with greater than or equal to 10 gallons of water stored. (See section IV.C.7 of this document for further discussion of the costs for instantaneous water heaters and hot water supply boilers.) Therefore, DOE analyzed both equipment classes of instantaneous water heaters and hot water supply boilers (less than 10 gallons and greater than or equal to 10 gallons stored volume) together for thermal efficiency standard levels in this final rule, which is discussed further in section IV.C.3 of this document.

DOE also determined that establishing standby loss standards for instantaneous water heaters and hot water supply boilers with less than or equal to 10 gallons water stored would result in minimal energy savings. Even if DOE were to account for the energy savings potential of amended standby loss standards for instantaneous water heaters and hot waters supply boilers with less than or equal to 10 gallons of water stored, the contribution any potential energy savings from amended standards for these units would be negligible and not appreciably impact the energy savings analysis for CWH equipment. Bradford White commented in support of DOE's determination not to establish standby loss standards for gas-fired instantaneous and hot water supply boilers less than 10 gallons. (Bradford White, No. 23 at p. 3) For instantaneous water heaters and hot water supply boilers (other than storage-type instantaneous water heaters), DOE has not found and did not receive any information or data suggesting that DOE should analyze amended standby loss standards.

Bradford White commented that there is confusion in how different types of products are characterized by DOE and stated that there appears to be overlap in the structure of the proposed standards. (Bradford White, No. 23 at p. 1) In particular, Bradford White stated that gas-fired storage-type instantaneous water heaters and gas-fired instantaneous water heaters are handled differently and that certain products appear to fall into the two different categories with two different sets of energy conservation standards. *Id*. AHRI stated that it understands that the Department's intent is for the equipment class of "instantaneous water heaters and hot water supply boilers greater than 10 gallons" to refer specifically to hot water supply boilers with storage tanks and circulating water heaters with an external storage tank. AHRI stated that including separate standards for "gas-fired storage water heaters and storage-type instantaneous water heaters" and "gas-fired instantaneous water heaters with a storage capacity greater than or equal to 10 gallons" in Table 1 to 10 CFR 431.110(a) of the May 2022 CWH ECS

NOPR could cause market confusion by creating unintentional overlap between these product types. (AHRI, No. 31 at pp. 2–3)

In response, DOE clarifies that in this final rule, it is adopting a minimum thermal efficiency of 95 percent for gas-fired storage-instantaneous water heaters and a minimum thermal efficiency of 96 percent for tankless water heaters and circulating water heaters and hot water supply boilers. As discussed in section IV.A.2.a of this document, gas-fired storage-type instantaneous water heaters were analyzed together with gas-fired storage water heaters because of the similarity of these types of equipment. Additionally, as discussed in section IV.A.2.c of this document, DOE analyzed tankless water heaters and circulating water heaters and hot water supply boilers as two separate kinds of representative equipment for this rulemaking analysis, to reflect the differences between these types of equipment, but they are part of the same equipment class (gas-fired instantaneous water heaters and hot water supply boilers), and DOE is adopting the same minimum efficiency requirements for these equipment in this final rule. Similarly, DOE notes that storage-type instantaneous water heaters are instantaneous water heaters that include a storage tank with a storage volume greater than or equal to 10 gallons. Other instantaneous water heaters may also have greater than or equal to 10 gallons but if that storage volume is included within the heat exchanger itself rather than a storage tank, they are not considered storage-type instantaneous water heaters.

C. Test Procedure

EPCA sets forth generally applicable criteria and procedures for DOE's adoption and amendment of test procedures. (42 U.S.C. 6314(a)) 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 test procedures for CWH equipment are specified at 10 CFR 431.106 and provide mandatory methods for determining the thermal efficiency, standby loss, and UEF, as applicable, of CWH equipment.[21] As discussed in the May 2022 CWH ECS NOPR, DOE analyzed standards for residential-duty gas-fired storage water heaters in terms of UEF. However, on January 11, 2022, DOE published a test procedure NOPR for consumer water heaters and residential-duty commercial water heaters. 87 FR 1554. Subsequently, on July 14, 2022, DOE published a supplemental NOPR ("SNOPR") ("the July 2022 SNOPR") proposing to amend the test procedure for consumer water heaters and residential-duty commercial water heaters. 87 FR 42270. Finally, on June 21, 2023, DOE published the final rule ("the June 2023 TP Final Rule") amending the test procedure for consumer water heaters and residential-duty commercial water heaters. 88 FR 40406.

[21] "Thermal efficiency" for an instantaneous water heater, a storage water heater or a hot water supply boiler means the ratio of the heat transferred to the water flowing through the water heater to the amount of energy consumed by the water heater as measured during the thermal efficiency test procedure prescribed in this subpart. "Standby loss" means: (1) For electric commercial water heating equipment (not including commercial heat pump water heaters), the average hourly energy required to maintain the stored water temperature expressed as a percent per hour (%/h) of the heat content of the stored water above room temperature and determined in accordance with appendix B or D to subpart G of part 431 (as applicable), denoted by the term "S"; or (2) For gas-fired and oil-fired commercial water heating equipment, the average hourly energy required to maintain the stored water temperature expressed in British thermal units per hour (Btu/h) based on a 70 °F temperature differential between stored water and ambient room temperature and determined in accordance with appendix A or C to subpart G of part 431 (as applicable), denoted by the term "SL." 10 CFR 431.102.

In response to the May 2022 CWH ECS NOPR, DOE received several comments relating to the proposed test procedure amendments. A.O. Smith stated that they do not anticipate any meaningful impact on future energy efficiency ratings for residential-duty commercial water heaters resulting from the proposed changes. (A.O. Smith, No. 22 at p. 5) However, DOE also received several comments stating that the proposed changes could cause impacts to the efficiency ratings of residential-duty commercial water heaters. In particular, AHRI expressed concern about changes to how effective storage volume is calculated, how internal tank temperature is determined, the ramifications of overheating on ratings, and the definition of demand response. (AHRI, No. 31 at p. 3) Bradford White commented that they were still assessing the potential impacts of the proposed test procedure amendments but noted that a few of the proposed changes could possibly greatly impact the efficiency ratings. (Bradford White, No. 23 at p. 7). Rheem similarly raised concerns that the test procedure amendments proposed in the July 2022 SNOPR could impact efficiency ratings for residential-duty water heaters, and encouraged DOE to issue the final rule of the consumer water heater test procedure at least 180 days prior to the issuance of a CWH energy conservation standards rule, as recommended by the Process Rule provisions in section (8)(d)(10) of appendix A to subpart C of part 430. (Rheem, No. 24 at p. 4) The Joint Gas Commenters stated that completing the residential-duty gas storage water heater test procedure rulemaking before completing the CWH standards rulemaking may be required by the Process Rule. (Joint Gas Commenters, No. 34 at p. 37)

In response, as discussed in the June 2023 TP Final Rule, DOE has concluded that the test procedure changes that were adopted in the June 2023 Final Rule will not alter the UEF ratings of residential-duty water heaters. 88 FR 40406, 40412. In addition, DOE notes that it has discretion to deviate from the procedures in appendix A in certain cases. DOE's rationale for deviating from the 180day requirement in appendix A is discussed in section II.C of this document.

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. *See generally* 10 CFR 431.4; sections 6(b)(3)(i) and 7(b)(1) of appendix A to 10 CFR part 430 subpart C ("Process Rule").

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. *See generally* 10 CFR 431.4; 10 CFR part 430, subpart C, appendix A, sections 6(c)(3)(ii)-(v) and 7(b)(2)-(5). Section IV.B of this document discusses the results of the screening analysis for CWH equipment, 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 an amended standard for a type or class of covered equipment, it determines the maximum improvement in energy efficiency or maximum reduction in energy use that is technologically feasible for such equipment. Accordingly, in the engineering analysis, DOE determined the max-tech improvements in energy efficiency for CWH equipment, 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.4 of this final rule and in chapter 5 of the final rule TSD.

E. Energy Savings

1. Determination of Savings

For each TSL, DOE projected energy savings from application of the TSL to CWH equipment purchased in the 30-year period that begins in the year of compliance with the amended standards (2026–2055 for gas-fired CWH equipment).[22] The savings are measured over the entire lifetime of CWH equipment purchased in the 30-year analysis period. DOE quantified the energy savings attributable to each TSL as the

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

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 CWH equipment. 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 NES 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 because they are supplied to the user without transformation from another form of energy.

DOE also calculates NES in terms of FFC energy savings. The FFC metric 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 conservation standards.[23] DOE's approach is based on the calculation of an FFC multiplier for each of the energy types used by covered equipment.[24] For more information on FFC energy savings, see section IV.H.3 of this document.

[23] 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).
[24] Natural gas and electricity were the energy types analyzed in the FFC calculations.

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. (*See* 42 U.S.C. 6313(a)(6)(C)(i); 42 U.S.C. 6313(a)(6)(A)(ii)(II)) [25]

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. [26] For example, some covered products and equipment have most of their energy consumption occur during periods of peak energy demand. The impacts of this equipment on the energy infrastructure can be more pronounced than equipment 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 0.70 quads. Based on the amount of FFC savings, the

[25] In setting a more stringent standard for ASHRAE equipment, DOE must have "clear and convincing evidence" that doing so "would result in significant additional conservation of energy" in addition to being technologically feasible and economically justified. 42 U.S.C. 6313(a)(6)(A)(ii)(II). This language indicates that Congress had intended for DOE to ensure that, in addition to the savings from the ASHRAE standards, DOE's standards would yield additional energy savings that are significant. In DOE's view, this statutory provision shares the requirement with the statutory provision applicable to covered products and non-ASHRAE equipment that "significant conservation of energy" must be present (42 U.S.C. 6295(o)(3)(B)) —and supported with "clear and convincing evidence"—to permit DOE to set a more stringent requirement than ASHRAE.

[26]The numeric threshold for determining the significance of energy savings established in a final rule published on February 14, 2020 (85 FR 8626, 8670) was subsequently eliminated in a final rule published on December 13, 2021 (86 FR 70892).

corresponding reduction in emissions, and need to confront the global climate crisis, DOE has determined (based on the methodology described in section IV.E of this document and the analytical results presented in section V.B.3.a of this document) that there is clear and convincing evidence that the energy savings from the standard levels adopted in this final rule are "significant" within the meaning of 42 U.S.C. 6313(a)(6)(A)(ii)(II).

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. 6313(a)(6)(B)(ii)(I)-(VII) and (C)(i)) The following sections discuss how DOE has addressed each of those seven factors in this rulemaking.

a. Economic Impact on Manufacturers and Consumers

EPCA requires DOE to consider the economic impact of a standard on manufacturers and the consumers of the products subject to the standard. (42 U.S.C. 6313(a)(6)(B)(I) and (C)(i)) In determining the impacts of potential amended standards on manufacturers, DOE conducts an MIA, as discussed in section IV.J of this document. For the MIA, 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 (manufacturer subgroups), 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 NPV of the economic impacts applicable to a particular rulemaking. DOE also evaluates the impacts of potential standards on identifiable subgroups of consumers that may be affected disproportionately by a national 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 CWH equipment 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. 6313(a)(6)(B)(ii)(II); 42 U.S.C. 6313(a)(6)(C)(i)) DOE conducts this comparison in its LCC and PBP analysis.

The LCC is the sum of the purchase price of a piece of equipment (including its installation and sales tax) and the operating expense (including energy, maintenance, and repair expenditures) discounted over the lifetime of the equipment. 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 equipment lifetime and discount rate, DOE uses a distribution of values, with probabilities attached to each value. For its analysis, DOE assumes that consumers will purchase the covered equipment in the first full year of compliance with amended standards.

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.

The LCC savings for the considered efficiency levels are calculated relative to the no-new-standards case that reflects projected market trends in the absence of new or amended standards. DOE identifies the percentage of consumers estimated to receive LCC savings or experience an LCC increase, in addition to the average LCC savings associated with a particular standard level. 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. 6313(a)(6)(B)(ii)(III)) As discussed in section IV.H of this document and chapter 10 of the final rule TSD, DOE uses the NIA spreadsheet models to project national energy savings.

d. Lessening of Utility or Performance of Products

In establishing classes of equipment, and in evaluating design options and the impact of potential standard levels, DOE must consider any lessening of the utility or performance of the considered equipment likely to result from the standard. (42 U.S.C. 6313(a)(6)(B)(ii)(IV)) Based on data available to DOE, the standards in this document would not reduce the utility or performance of the products under consideration in this rulemaking. As discussed in section IV.A.2.b of this document, DOE considered whether different venting technologies should be considered a necessary feature.

Although the standards in this final rule would effectively eliminate non-condensing technology (and associated venting), DOE has recently published a final interpretive rule that returns to the previous and long-standing interpretation (in effect prior to the January 15, 2021 final interpretive rule), under which the technology used to supply heated air or hot water is not a performance-related "feature" that provides a distinct utility under EPCA. 86 FR 73947 (Dec. 29, 2021). Therefore, for the purpose of the analysis conducted for this rulemaking, DOE has determined that it is not prohibited from setting energy conservation standards that preclude non-condensing technology and did not analyze separate equipment classes for non-condensing and condensing CWH equipment in this final rule. A more detailed explanation of DOE's determination may be found in section IV.A.2 of this document.

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. (*See* 42 U.S.C. 6313(a)(6)(B)(ii)(V)) 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 CWH equipment 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.

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. 6313(a)(6)(B)(ii)(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. As part of the analysis of the need for national energy and water conservation, 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.[27] DOE also estimates the economic value of emissions reductions resulting from the considered TSLs, as discussed in section IV.L of this document. DOE emphasizes that the SC-GHG analysis presented in this final rule and TSD was performed in support of the cost-benefit analyses required by Executive Order ("E.O.") 12866, and is provided to inform the public of the impacts of emissions reductions resulting from this rule. The SC-GHG estimates were not factored into DOE's EPCA analysis of the need for national energy and water conservation.

[27] As discussed in section IV.L of this document, for the purpose of complying with the requirements of E.O. 12866, DOE also estimates the economic value of emissions reductions resulting from the considered TSLs. DOE calculates this estimate using a measure of the social cost ("SC") of each pollutant (*e.g.*, SC-CO_2). Although this estimate is calculated for the purpose of complying with E.O. 12866, the Seventh Circuit Court of Appeals confirmed in 2016 that DOE's consideration of the social cost of carbon in energy conservation standards rulemakings is permissible under EPCA. *Zero Zone v. Dept of Energy*, 832 F.3d 654, 678 (7th Cir. 2016).

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. 6313(a)(6)(B)(ii)(VII) and (C)(i)) DOE did not consider other factors for this document.

2. Rebuttable Presumption

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 effects that potential amended energy conservation standards would have on the PBP for consumers. These analyses include, but are not limited to, the 3-year PBP 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. 6313(a)(6)(B)(ii) and 42 U.S.C. 6313(a)(6)(C)(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 V.B.1.c of this document.

G. Revisions to Notes in Regulatory Text

In the May 2022 CWH ECS NOPR, DOE proposed to modify the three notes to the table of energy conservation standards in 10 CFR 431.110. 87 FR 30610, 30626–30627. First, DOE proposed to modify the note to the table of energy conservation standards denoted by subscript "a" to replace the term "nameplate input rate" with the term "rated input." DOE noted that this change ensures consistency in nomenclature throughout DOE's regulations for CWH equipment. *Id.*

DOE also proposed in the May 2022 CWH ECS NOPR to remove the note to the table of energy conservation standards denoted by subscript "b." This note clarifies the compliance date for energy conservation standards for hot water supply boilers with capacity less than 10 gallons. However, the note is no longer needed because the specific compliance date for hot water supply boilers with less than 10 gallons of storage is well in the past, with all such equipment being required to meet the standards in the table in 10 CFR 431.110 since October 21, 2005. *Id*.

In the May 2022 CWH ECS NOPR, DOE also proposed to modify the note to the table of energy conservation standards denoted by subscript "c," which establishes design requirements for water heaters and hot water supply boilers having more than 140 gallons of storage capacity that do not meet the standby loss standard. DOE proposed to replace the phrase "fire damper" with the phrase "flue damper," because "flue damper" was more consistent with commonly used terminology and likely the intended meaning, and that "fire damper" was a typographical error. 87 FR 30610, 30626–30627. This revised footnote, new footnote b on Table 1 to 10 CFR 431.110(a), was inadvertently omitted in the May 2022 CWH ECS NOPR. DOE did not intend to remove this footnote and is retaining that footnote in this final rule.

Finally, in the May 2022 CWH ECS NOPR, DOE proposed to add a footnote to Table 1 at 10 CFR 431.110(a) (new footnote c) to clarify that the compliance date for energy conservation standards for electric instantaneous water heaters is January 1, 1994. 87 FR 30610, 306728. As discussed in section III.B.3 of this document, DOE is codifying standards for electric instantaneous water heaters that were originally set by EPCA but were inadvertently omitted in DOE's regulations at 10 CFR 431.110.

In response to the May 2022 CWH ECS NOPR, Bradford White stated that they support DOE's decision not to change the requirements for a model's rated input. (Bradford White, No. 23 at p. 8) WM Technologies and Patterson-Kelley also indicated support for using the term "rated input", as long as the method to determine this value is unchanged. They also encouraged DOE to maintain the "b" and "c" subscripts for posterity to maintain chronological information. (WM Technologies, No. 25 at p. 7; Patterson-Kelley No. 26 at p. 5) In response, DOE notes that the Electronic Code of Federal Regulations (eCFR)[28] allows users to access historical versions of the CFR by using the "Timeline" or "Go to Date" functions when viewing a page of the CFR. Therefore, because chronological information about changes to the CFR remain available

[28] The eCFR is available at *ecfr.gov*.

to the public, DOE does not consider it necessary to retain these notes in the current version of the CFR.

In footnote b(1), DOE is amending the text to refer to the existing definition of R-value in §431.102, rather than refer directly to industry standards in this note. This does not change the standards regarding standby loss, or the thermal insulation requirement as detailed in this note, but improves consistency and prevents future discrepancies between §431.102 and §431.110. DOE is adopting the changes to notes "b" and "c" as proposed in the May 2022 CWH ECS NOPR, with this editorial revision.

H. Certification, Compliance, and Enforcement Issues

In the withdrawn May 2016 CWH ECS NOPR, DOE proposed to add requirements to its certification, compliance, and enforcement regulations at 10 CFR 429.44 that the rated value of storage volume must equal the mean of the measured storage volume of the units in the sample. 81 FR 34440, 34458 (May 31, 2016). Additionally, in the withdrawn May 2016 CWH ECS NOPR, DOE proposed changes to the equations for maximum standby losses that would be consistent with the proposed changes to DOE's certification, compliance, and enforcement regulations. 81 FR 34440, 34458–34459. In the May 2022 CWH ECS NOPR, DOE explained that after considering comments from stakeholders related to this topic, it decided not to propose changes to the requirements regarding certification of storage volume or the related changes to the equations for maximum standby loss. 87 FR 30610, 30628.

Bock and Bradford White indicated support for DOE's proposal not to change the requirements regarding certification of storage volume for storage-type water heaters. (Bock, No. 20 at p. 1; Bradford White, No. 23 at p. 8) After considering the comments, DOE is not adopting any changes to the requirements regarding certification of storage volume in this final rule.

Additionally, in response to the May 2022 CWH ECS NOPR, Rheem recommended that the certification criteria at 10 CFR 429.44(c)(2) be amended to require manufacturers to state whether a basic model is a "storage-type instantaneous water heater." Rheem also recommended that DOE should publish an example certification template. (Rheem, No. 24 at p. 3) In response, DOE notes that manufacturers of commercial gas-fired and oil-fired instantaneous water heaters and hot water supply boilers with storage capacity greater than or equal to 10 gallons are already required to certify whether the water heater includes a storage tank with a storage volume greater than or equal to 10 gallons. 10 CFR 429.44(c)(2)(iv). Such units that include a storage tank with a storage volume greater than or equal to 10 gallons would meet DOE's definition of storage-type water heaters as set out at 10 CFR 431.102.

Lastly, in the May 2022 CWH ECS NOPR, DOE stated that it was not proposing to establish equipment-specific certification requirements for electric instantaneous water heaters, but may propose to establish certification requirements for electric instantaneous water heaters in future rulemakings. 87 FR 30610, 30628. DOE did not receive any comments related to this topic and is not establishing certification requirements specific to electric instantaneous water heaters in this final rule.

IV. Methodology and Discussion of Related Comments

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

In overview, 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 NIA uses a second spreadsheet set that provides shipments forecasts and calculates NES and NPV resulting from potential new or amended energy conservation standards.[29] These spreadsheet tools are available on the DOE website for this rulemaking: *www1.eere.energy.gov/buildings/appliance_standards/standards.aspx?productid=36*. 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

For the market and technology assessment for CWH equipment, DOE gathered information in the market and technology assessment that provides an overall picture of the market for the equipment concerned, including the purpose of the equipment, the industry structure, manufacturers, market characteristics, and technologies used in the equipment. This activity includes both quantitative and qualitative assessments, based primarily on publicly-available information. The subjects addressed in the market and

[29] DOE uses a third spreadsheet tool, the Government Regulatory Impact Model ("GRIM"), to assess the financial impacts of potential new or amended standards on manufacturers.

technology assessment for this rulemaking include the following: (1) a determination of the scope of the rulemaking and equipment classes, (2) manufacturers and industry structure, (3) types and quantities of CWH equipment sold, (4) existing efficiency programs, and (5) technologies that could improve the energy efficiency of CWH equipment. 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. Definitions

EPCA includes the following categories of CWH equipment as covered industrial equipment: storage water heaters, instantaneous water heaters, and unfired hot water storage tanks. EPCA defines a "storage water heater" as a water heater that heats and stores water internally at a thermostatically-controlled temperature for use on demand. This term does not include units that heat with an input rating of 4,000 Btu per hour or more per gallon of stored water. EPCA defines an "instantaneous water heater" as a water heater that heats with an input rating of at least 4,000 Btu per hour per gallon of stored water. Lastly, EPCA defines an "unfired hot water storage tank" as a tank that is used to store water that is heated external to the tank. (42 U.S.C. 6311(12)(A)-(C))

DOE first codified the following more specific definitions for CWH equipment at 10 CFR 431.102 in the October 2004 direct final rule. 69 FR 61974, 61983. Several of these definitions were subsequently amended in the November 2016 CWH TP final rule. 81 FR 79261, 79287–79288 (Nov. 10, 2016).

Specifically, DOE now defines "hot water supply boiler" in 10 CFR 431.102 as a packaged boiler that is industrial equipment and that (1) has an input rating from 300,000 Btu/h to 12,500,000 Btu/h and of at least 4,000 Btu/h per gallon of stored water; (2) is suitable for heating potable water; and (3) meets either or both of the following conditions: (i) it has the temperature and pressure controls necessary for heating potable water for purposes other than space heating; or (ii) the manufacturer's product literature, product markings, product marketing, or product installation and operation instructions indicate that the boiler's intended uses include heating potable water for purposes other than space heating.

DOE also defines an "instantaneous water heater" in 10 CFR 431.102 as a water heater that uses gas, oil, or electricity, including: (1) gas-fired instantaneous water heaters with a rated input both greater than 200,000 Btu/h and not less than 4,000 Btu/h per gallon of stored water; (2) oil-fired instantaneous water heaters with a rated input both greater than 210,000 Btu/h and not less than 4,000 Btu/h per gallon of stored water; and (3) electric instantaneous water heaters with a rated input both greater than 12 kW and not less than 4,000 Btu/h per gallon of stored water.

DOE defines a "storage water heater" in 10 CFR 431.102 as a water heater that uses gas, oil, or electricity to heat and store water within the appliance at a thermostatically-controlled temperature for delivery on demand including: (1) gas-fired storage water heaters with a rated input both greater than 75,000 Btu/h and less than 4,000 Btu/h per gallon of stored water; (2) oil-fired storage water heaters with a rated input both greater than 105,000 Btu/h and less than 4,000 Btu/h per gallon of stored water; and (3) electric storage water heaters with a rated input both greater than 12 kW and less than 4,000 Btu/h per gallon of stored water.

Lastly, DOE defines an "unfired hot water storage tank" in 10 CFR 431.102 as a tank used to store water that is heated externally, and that is industrial equipment.

Relating to these definitions, Rheem recommended that the definition of "storage-type instantaneous water heater" at 10 CFR 431.102 should be based on "rated storage volume" and that the certification criteria at 10 CFR 429.44 be amended to be based on "measured storage volume." (Rheem, No. 24 at p. 3) DOE agrees that basing the categorizations of storage-type instantaneous water heaters based on the rated storage volume is consistent with the criteria DOE uses to identify such equipment. Therefore, DOE is amending the definition of "storage-type instantaneous water heater" at 10 CFR 431.102 to clarify that the storage volume refers to the rated storage volume. However, as discussed in section III.H of this document, DOE has decided not to amend its requirements regarding certification of storage volume of commercial water heaters (including storage-type instantaneous water heaters) in this final rule. Rheem also suggested that DOE's requirements for non-storage-type commercial gas-fired instantaneous water heaters at 10 CFR 429.44(C)(2)(iv) be changed so that manufacturers are required to state whether a calculation-based method was used to determine the "rated storage volume" instead of the "measured storage volume." (Rheem, No. 24 at p. 3) Consistent with its decision not to address certification requirements in this final rule, DOE is not making such clarification in this final rule. However, DOE may consider a clarification to this certification language in a separate rulemaking.

2. Equipment Classes

When evaluating and establishing energy conservation standards, DOE divides covered equipment into equipment classes by the type of energy used. DOE will also establish separate equipment classes if a group of equipment has a capacity or other performance-related feature that other equipment within such type do not have and such feature justifies a different standard. (42 U.S.C. 6295(q); 42 U.S.C. 6316(a)) In determining whether a performance-related feature justifies a different standard, DOE considers such factors as the utility to the consumers of the feature and other factors DOE determines are appropriate.

CWH equipment classes are divided based on the energy source, equipment category (*i.e.*, storage vs. instantaneous and hot water supply boilers), and size (*i.e.*, input capacity and rated storage volume). Unfired hot water storage tanks are also included as a separate equipment class, but as discussed in section III.B.2 of this rulemaking, were considered as part of a separate proceeding and therefore were not analyzed for this final rule. Table IV.1 shows the current equipment classes and energy conservation standards for CWH equipment other than residential-duty commercial water heaters, and Table IV.2 shows DOE's current equipment classes and energy conservation standards for residential-duty commercial water heaters. [30]

[30] Consumer water heaters are separately covered products that are distributed in commerce for personal use or consumption by individuals, as opposed to commercial applications. These products generally have lower input ratings than commercial water heaters. Energy conservation standards for consumer water heaters can be found at 10 CFR 430.32(d), and the test procedure for these products can be found at appendix E to subpart B of 10 CFR part 430. Residential-duty commercial water heaters are commercial water heater that meet additional criteria, including using only single-phase electrical power (if they use

Table IV.1 Current Equipment Classes and Energy Conservation Standards for CWH Equipment Except for Residential-Duty Commercial Water Heaters

Equipment Class	Size	Energy Conservation Standards*	
		Minimum Thermal Efficiency (equipment manufactured on and after Oct. 9, 2015)**, ***	Maximum Standby Loss (equipment manufactured on and after Oct. 29, 2003)**,†
Electric storage water heaters	All	N/A	$0.30 + 27/V_m$ (%/h)
Gas-fired storage water heaters	≤155,000 Btu/h	80%	$Q/800 + 110(V_r)^{1/2}$ (Btu/h)
	>155,000 Btu/h	80%	$Q/800 + 110(V_r)^{1/2}$ (Btu/h)
Oil-fired storage water heaters	≤155,000 Btu/h	80%***	$Q/800 + 110(V_r)^{1/2}$ (Btu/h)
	>155,000 Btu/h	80%***	$Q/800 + 110(V_r)^{1/2}$ (Btu/h)
Electric instantaneous water heaters‡	<10 gal	80%	N/A
	≥10 gal	77%	$2.30 + 67/V_m$ (%/h)
Gas-fired instantaneous water heaters and hot water supply boilers	<10 gal	80%	N/A
	≥10 gal	80%	$Q/800 + 110(V_r)^{1/2}$ (Btu/h)
Oil-fired instantaneous water heater and hot water supply boilers	<10 gal	80%	N/A
	≥10 gal	78%	$Q/800 + 110(V_r)^{1/2}$ (Btu/h)
		Minimum Thermal Insulation	
Unfired hot water storage tank	All	R-12.5	

* Vm is the measured storage volume, and Vr is the rated volume, both in gallons. Q is the nameplate input rate in Btu/h.

** For hot water supply boilers with a capacity of less than 10 gallons: (1) the standards are mandatory for products manufactured on and after October 21, 2005 and (2) products manufactured prior to that date, and on or after October 23, 2003, must meet either the standards listed in this table or the applicable standards in subpart E of part 431 for a "commercial packaged boiler."

*** For oil-fired storage water heaters: (1) the standards are mandatory for equipment manufactured on and after October 9, 2015 and (2) equipment manufactured prior to that date must meet a minimum thermal efficiency level of 78 percent.

† Water heaters and hot water supply boilers having more than 140 gallons of storage capacity need not meet the standby loss requirement if: (1) the tank surface area is thermally insulated to R-12.5 or more, (2) a standing pilot light is not used, and (3) for gas or oil-fired storage water heaters, they have a fire damper or fan-assisted combustion.

‡ Energy conservation standards for electric instantaneous water heaters are included in EPCA. In this final rule, DOE codifies these standards for electric instantaneous water heaters in its regulations at 10 CFR 431.110. Further discussion of standards for electric instantaneous water heaters is included in section III.B.3 of this document.

electricity) and not being designed to heat water at temperatures greater than 180 °F, as discussed in the footnotes to Table IV.2 of this document.

Table IV.2 Current Equipment Classes and Energy Conservation Standards for Residential-Duty Commercial Water Heaters

Equipment	Specification*	Draw Pattern**	Uniform Energy Factor
Gas-fired Storage	>75 kBtu/h and ≤105 kBtu/h and ≤120 gal and ≤180 °F	Very Small	0.2674 - (0.0009 x V_r)
		Low	0.5362 - (0.0012 x V_r)
		Medium	0.6002 - (0.0011 x V_r)
		High	0.6597 - (0.0009 x V_r)
Oil-fired storage	>105 kBtu/h and ≤140 kBtu/h and ≤120 gal and ≤180 °F	Very Small	0.2932 - (0.0015 x V_r)
		Low	0.5596 - (0.0018 x V_r)
		Medium	0.6194 - (0.0016 x V_r)
		High	0.6740 - (0.0013 x V_r)
Electric instantaneous	>12 kW and ≤58.6 kW and ≤2 gal and ≤180 °F	Very Small	0.80
		Low	0.80
		Medium	0.80
		High	0.80

* To be classified as a residential-duty water heater, a commercial water heater must, if requiring electricity, use single-phase external power supply, and not be designed to heat water at temperatures greater than 180 °F.
** Draw pattern is a classification of hot water use of a consumer water heater or residential-duty commercial water heater, based upon the first-hour rating. The draw pattern is determined using the *Uniform Test Method for Measuring the Energy Consumption of Water Heaters* in appendix E to subpart B of 10 CFR part 430.

The following subsections include further discussion of comments received on equipment classes and DOE's approach to equipment classes for this final rule.

a. Storage-Type Instantaneous Water Heaters

Based on a review of equipment on the market, DOE has found that gas-fired storage-type instantaneous water heaters are very similar to gas-fired storage water heaters, but with a higher ratio of input rating to tank volume. This higher input-volume ratio is achieved with a relatively larger heat exchanger paired with a relatively smaller tank. Increasing either the input capacity or storage volume increases the hot water delivery capacity of the water heater. However, through a review of product literature, DOE did not identify any significant design differences that would warrant different energy conservation standard levels (for either thermal efficiency or standby loss) between models in these two equipment classes. Therefore, DOE grouped the two equipment classes together in the May 2022 CWH ECS NOPR analyses and proposed the same standard levels for each equipment class. 87 FR 30610, 30631–30632.

Barton Day Law questioned whether gas-fired storage water heaters and storage-type instantaneous water heaters can be categorized as the same product within the analysis, and whether the same numbers can be used to represent both product types. (Barton Day Law, Public Meeting Transcript No. 13 at p. 23) However, Barton Day Law did not provide any specific reasons that these products are functionally different. In contrast, the Joint Advocates agreed with DOE's methodology for analyzing equipment types and stated that it was appropriate to analyze commercial gas-fired storage and storage-type instantaneous water heaters together due to the commonalities in design and shared features. (The Joint Advocates, No. 29 at pp. 1, 2)

As noted, DOE has found that gas-fired storage-type instantaneous water heaters have a higher ratio of input rating to tank volume than gas-fired storage water heaters (*i.e.*, the ratio exceeds the 4,000 Btu/h per gallon of stored water threshold included in the definition of instantaneous water heaters at 10 CFR 431.102). However, through a review of product literature, neither DOE nor any commenters identified any significant design differences that would warrant different energy conservation standard levels (for either thermal efficiency or standby loss) between models in these two equipment classes. Therefore, DOE continued to group the two equipment classes together in this final rule.

The standard levels considered in this document reflect the similarity of these types of equipment, with the same standard levels considered for both storage water heaters and storage-type instantaneous water heaters.

b. Venting for Gas-Fired Water Heating Equipment

In response to the May 2022 CWH ECS NOPR, Patterson-Kelley and WM Technologies stated that increasing efficiencies beyond the capabilities of Category I Venting as defined in the National Fuel Gas Code NFPA 54 will result in the unavailability of products that use category I venting. (Patterson-Kelley, No. 26 at pp. 1–2; WM Technologies, No. 25 at p. 2) Patterson-Kelley explained that converting to Category I appliances may be costly and application prohibitive in establishments in densely populated areas. (Patterson-Kelley, No. 26 at p. 2) The Joint Gas Commenters stated that DOE's treatment of venting issues raised by condensing-level standards is unreasonable and contrary to law. Specifically, the Joint Gas Commenters described that the imposition of standards that non-condensing products cannot achieve would raise significant practical, economic, and legal issues. Cumulatively, they said, inaccurate assumptions undermine the May 2022 CWH ECS NOPR's economic evaluation and its estimate of the market impacts of the proposed standards. (The Joint Gas Commenters, No. 34 at p. 3)

Similarly, the Joint Gas Commenters argued that venting type is indeed a performance feature and pointed to the January 2021 Final Rule for Residential Furnaces and Commercial Water Heaters that agreed with this logic but has since been withdrawn. (Joint Gas Commenters, No. 34 at p. 10) Patterson-Kelley and WM Technologies agreed and commented that they maintain the same justification per 42 U.S.C. 6295 (q)(l) documented in the Final Interpretive Rule provided in 86 FR 4776 applies to fuel-fired commercial water heaters. As such, Patterson-Kelley and WM Technologies also continue to support DOE's January 2021 acceptance of the Gas Industry Petition to recognize non-condensing as a product feature per EPCA. (WM Technologies, No. 25 at p. 2; Patterson-Kelly, No. 26 at pp. 1–2) WM Technologies believes that 42 U.S.C. 6313(a)(6)(B)(II)(aa) prohibits the elimination of non-condensing water heaters. (WM Technologies, No. 25 at p. 1) The Joint Gas Commenters further claimed that DOE should recognize the compatibility of a product with the existing atmospheric venting systems is a performance-related feature that would require separate standards for condensing and non-condensing products if standards specific to condensing products are justified. (The Joint Gas Commenters, No. 34 at p. 11) They explained that DOE is precluded by EPCA from amending standards in such a way that renders existing venting systems unusable by eliminating products consistent with the venting type. (Joint Gas Commenters, No. 34 at p. 10) The Joint Gas Commenters stated that Congress understood that buildings are designed to accommodate standard installations and sought to ensure that standards would not deprive consumers of the utility and convenience of products that can be installed without the need to modify the existing buildings to accommodate them. *Id*. The Joint Gas Commenters drew parallels between the question of vent-type consistency and other instances in which DOE avoided setting standards that would make it impossible for consumers to install a space constrained product. *Id*. The Joint Gas Commenters requested that any final rule in this proceeding include a written finding that interested persons have established by a preponderance of the evidence that the proposed standards are likely to result in the unavailability in the United States of commercial water heaters with "performance characteristics (including reliability, features, sizes, capacities, and volumes) that are substantially the same as those generally available in the United States" on the date any such rule issues. (Joint Gas Commenters, No. 34 at p. 11)

PHCC similarly noted that they have on prior occasion expressed concern for the elimination of non-condensing technology for commercial gas fire water heaters. They believe that there are numerous parts of the May 2022 CWH ECS NOPR that are overly optimistic, do not reflect current market conditions, make inaccurate assumptions, and minimize installation issues for condensing type products. (PHCC, No. 28 at p. 1)

Patterson-Kelley stated that hybridization of standard efficiency and high efficiency products would be a low-cost migration to the efficiencies the DOE is looking for, while mitigating the cost of full conversions of the system. They noted that this would also allow for proper analysis of the correctly sized equipment for the space commercially and would further increase the system level efficiency, which is the ultimate goal. (Patterson-Kelley, No. 26 at p. 2) Addressing many of the same concepts as the Joint Gas Commenters, the CA IOUs instead expressed support for DOE's arguments; they agreed with analyzing both venting and condensing gas water heaters together, and with DOE's withdrawal of the Condensing Products Interpretive Rule. The commenters added that their commissioned research with other utility partners shows it is always possible to retrofit a non-condensing gas water heater with a condensing product. (CA IOUs, No. 33 at p. 5) The CEC also indicated support for DOE's analysis, noting that DOE's application of its rule interpreting EPCA's "features provision" is lawful. (CEC, No. 27 at p. 3)

Under EPCA, DOE may not prescribe an amended standard if interested persons have established by a preponderance of the evidence that a standard is likely to result in the unavailability in the United States in any 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. 6313(a)(6)(B)(iii)(II)). Commenters have not provided, and DOE has not found, any evidence that eliminating CHWs that use category I venting would result in the unavailability of CWH models of substantially the same reliability, sizes, capacities, or volumes as those generally available in the current market. As demonstrated in chapter 3 of the TSD accompanying this final rule, condensing-level CWH equipment is generally available in the same capacities and volumes as noncondensing CWH equipment. With respect to reliability, all available data that DOE has reviewed suggest that the lifetimes of condensing CWH equipment are substantially the same as noncondensing CWH equipment. DOE notes that it does have, and has incorporated, data regarding increased repair costs for individual component failures that may occur in higher-efficiency condensing equipment, as discussed in section IV.F.5.b of this document.[31] However, the increased repair costs are largely related to the increased component cost and even in the case of heat exchangers where DOE cites a higher failure rate, such does not translate

[31] Repair costs are based on annual failure rates of combustion systems and controls. Increased repair costs reflect increased costs for combustion systems and controls found in high efficiency CWH equipment, as well as increased frequency of repair for high efficiency controls. Heat exchanger replacement was also considered for commercial gas-fired instantaneous circulating water heaters and hot water supply boilers.

directly to decreased product life. Moreover, DOE has not found a decrease in product performance over the life of condensing models dissimilar from what would be expected in noncondensing CWH equipment. As discussed in IV.F.6 of this document, DOE has found that, within each equipment class, the average lifetime of all equipment covered by this rulemaking is the same for all thermal efficiency levels, from baseline through max-tech. Thus, DOE believes the reliability of condensing and noncondensing CWH equipment, in terms of equipment performance and ability to serve the hot water loads and in terms of overall lifetime, is substantially the same, and that there are no known reliability concerns endemic to condensing technology.

With respect to commenters' statements that category I venting itself is a performance characteristic that DOE's standards cannot make unavailable, 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 (condensing or noncondensing). As such, assuming venting is a performance characteristic, a standard would have to eliminate all vented gas-fired water heaters on the market—i.e., both condensing and non-condensing models—to run afoul of the unavailability provision in EPCA. Thus, in order to meet the unavailability requirements in 42 U.S.C. 6313(a)(6)(B)(iii)(II), Joint Gas Commenters and others are requesting DOE determine that a specific type of venting is a performance characteristic.

In response, DOE first notes that almost every component of a covered product or equipment could be broken down further by any of a number of factors. For example, heat exchangers, which are used in a variety of covered equipment and 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-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*.

As discussed in the December 2021 final interpretive rule, DOE believes that a consumer would be aware of performance-related features of a covered product or equipment and would recognize such features as providing additional benefits during operation of the covered product or equipment. 86 FR 73955. 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 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 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).

Joint Gas Commenters and others have not pointed to any additional benefits during operation offered by CWHs that use Category I venting as compared to CWHs that use other types of venting. Instead, these commenters cite the January 2021 final interpretive rule and economic considerations as reasons why Category I venting should be considered a performance characteristic for the purposes of EPCA's unavailability provision. With regards to the January 2021 final rule, DOE cited the potential for increased fuel switching and the potential need for significant modifications during installation as support for revising the Department's long-standing interpretation that Category 1 venting is not a performance-related feature. 86 FR 4816. DOE's response to these issues remains largely the same from the December 2021 final interpretive rule. First, as explained in the December 2021 final interpretive rule, the potential for increased fuel switching is simply not a performance characteristic that could serve as the basis for an unavailability finding under EPCA.

Second, with regards to the potential need for significant modifications during installation, this argument overlaps with other comments focused on the economic impacts of installation scenarios where existing Category I venting systems need to be replaced with a venting system suitable for a condensing CWH. DOE acknowledges that a condensing water heater may not be operated if installed with a non-condensing venting system, and that potentially complex replacement or modification of these venting systems will typically be required at a cost (as discussed in more detail in sections IV.F.2.c and IV.F.2.d. of this document). However, while using existing venting can reduce installation costs, it does not provide the consumer with any additional benefits during operation. Further, EPCA specifically directs DOE to consider installation and operating costs as part of the Department's determination of economic justification (*see* 42 U.S.C. 6313(a)(6)(B)(ii)(II)). As a result, there is a clear distinction in EPCA between the purposes of the unavailability provision in 42 U.S.C. 6313(a)(6)(B)(iii)(II)—to preserve performance-related features in the market—and the economic justification requirement in 42 U.S.C. 6313(a)(6)(B)(ii)—to determine whether the benefits (*e.g.*, reduced fuel costs for an appliance) of a proposed standard exceed the burdens (*e.g.*, increased installed cost). Thus, the appropriate analysis to determine whether less-efficient, non-condensing CWHs that use Category I venting should remain in the market is the economic justification analysis under 42 U.S.C. 6313(a)(6)(B)(ii). Accordingly, DOE has conducted such an analysis as part of the standards amendment process for this rulemaking. DOE analyzed ventilation installation and cost issues in the May 2022 CWH ECS NOPR, and does so again in this final rule. DOE's consideration of these issues and responses to associated comments may be found in section IV.F.2 of this document.

For these reasons, DOE disagrees with commenters that eliminating noncondensing CWHs that use Category I venting from the market would violate EPCA's "unavailability" provision as that technology does not provide unique utility to consumers that is not substantially the same as that provided by condensing CWH equipment. Accordingly, for the purpose of the analysis conducted for this rulemaking, DOE did not analyze separate equipment classes for non-condensing and condensing CWH equipment in this final rule.

c. Tankless Water Heaters and Hot Water Supply Boilers

In the May 2022 CWH ECS NOPR, DOE analyzed "tankless water heaters" and "circulating water heaters and hot water supply boilers" as two separate kinds of representative equipment in the gas-fired instantaneous water heaters equipment class, in order to reflect the differences in design and application between these kinds of equipment. DOE also presented analytical results separately for the two types of representative equipment. 87 FR 30610, 30632. In the June 23, 2022 public meeting, Barton Day Law questioned whether commercial instantaneous water heaters and hot water supply boilers can be appropriately categorized as the same product within DOE's analysis. (Barton Day Law, Public Meeting Transcript No. 13 at pp. 18–22)

In response, DOE notes that its analysis does account for the differences between these product types by including different installation costs for each. Tankless water heaters are typically flow-activated, wall-mounted, used without a storage tank, and capable of higher temperature rises. Circulating water heaters and hot water supply boilers, conversely, are typically used with a storage tank and recirculation loop, thermostatically-activated, and typically floor-mounted. However, despite these differences, tankless water heaters and hot water supply boilers are grouped in the same equipment category because they share basic fundamental similarities: both kinds of equipment supply hot water in commercial applications with an input rate of at least 4,000 Btu/h per gallon of stored water, and both include heat exchangers through which incoming water flows and is heated by combustion flue gases that flow around the heat exchanger tubes.

Therefore, for this final rule, DOE maintained its approach of analyzing “tankless water heaters” and “circulating water heaters and hot water supply boilers” as two separate kinds of representative equipment in the gas-fired instantaneous water heaters equipment class, and presents analytical results separately for the two types of representative equipment in section V of this final rule, although DOE is not proposing to restructure the equipment classes.[32]

d. Gas-Fired and Oil-Fired Storage Water Heaters

In the May 2022 CWH ECS NOPR, DOE proposed to consolidate commercial gas-fired and oil-fired storage water heater equipment classes that are currently divided by input rates of 155,000 Btu/h into two equipment classes without an input rate

[32] In the May 2022 CWH ECS NOPR, DOE responded to comments on the May 2016 CWH ECS NOPR. DOE received comments suggesting that DOE should split up the equipment class for gas-fired instantaneous water heaters and hot water supply boilers by input capacity, similar to DOE’s current energy conservation standards for commercial packaged boilers. 87 FR 30633. As noted in the May 2022 CWH ECS NOPR, ASHRAE 90.1 does not divide the equipment classes for commercial gas-fired instantaneous water heaters and hot water supply boilers by input capacity. Therefore, DOE did not, in the NOPR, and has not in this final rule, analyzed separate classes for gas-fired instantaneous water heaters and hot water supply boilers equipment class by input capacity.

distinction: (1) gas-fired storage water heaters and (2) oil-fired storage water heaters. DOE noted that this class structure would be consistent with the equipment class structure in the latest version of ASHRAE Standard 90.1. 87 FR 30610, 30633. In response Bradford White agreed with combining the classes for gas-fired storage water heaters above and below 155,000 Btu/h and noted that the historical reasons for the requirements being separated are no longer applicable. (Bradford White, No. 23 at p. 1) Bock Water Heaters and Rheem similarly indicated support for DOE removing the 155,000 Btu sizing categories from the energy conservation standards tables. (Bock Water Heaters, No. 20 at p. 1; Rheem, No. 24 at p. 2) AHRI also expressed support for the proposal and noted that these categories had no efficiency differences and separating them adds unnecessary complexity. (AHRI, No. 31 at p. 3) DOE is adopting this proposal in this final rule and is removing the input rate size distinctions for commercial gas-fired and oil-fired storage water heaters.

e. Grid-Enabled Water Heaters

In the May 2022 CWH ECS NOPR, DOE explained that it was not proposing to establish a separate equipment class for grid-enabled electric storage water heaters (*i.e.*, electric storage water heaters that can receive and react to commands sent from local utilities and which could at a minimum reduce their instantaneous power consumption in response) because DOE did not propose to amend the standard for commercial electric storage water heaters, and because a grid-enabled water heater would not be differentially impacted by a standby loss standard. 87 FR 30610, 30633. Bradford White agreed with DOE's decision not to establish a separate class for grid-enabled water heaters.

(Bradford White, No. 23 at p. 1) DOE maintains its position from the May 2022 CWH ECS NOPR and is not establishing a separate class for grid-enabled water heaters.

3. Review of the Current Market for CWH Equipment

In order to gather information needed for the market assessment for CWH equipment, DOE consulted a variety of sources, including manufacturer literature, manufacturer websites, the AHRI Directory of Certified Product Performance,[33] the CEC Appliance Efficiency Database,[34] and DOE's Compliance Certification Database.[35] DOE used these sources to compile a database of CWH equipment that served as resource material throughout the analyses conducted for this rulemaking. This database contained the following counts of unique models for which DOE analyzed for amended thermal efficiency standards: 431 commercial gas-fired storage water heaters, 44 residential-duty commercial gas-fired storage water heaters, 111 commercial gas-fired storage-type instantaneous water heaters (tank-type water heaters with greater than 4,000 Btu/h per gallon of stored water), 22 gas-fired tankless water heaters, and 280 gas-fired circulating water heaters and hot water supply boilers. Chapter 3 of the final rule TSD provides more information on the CWH equipment currently available on the market, including a full breakdown of these units into their equipment classes and graphs showing performance data.

[33] Last accessed on March 4, 2021 and available at *www.ahridirectory.org.*
[34] Last accessed on March 4, 2021 and available at cacertappliances.energy.ca.gov/Pages/ApplianceSearch.aspx.
[35] Last accessed on February 26, 2021 and available at *www.regulations.doe.gov/certification-data/.*

4. Technology Options

As part of the market and technology assessment, DOE uses information about commercially-available technology options and prototype designs to help identify technologies that manufacturers could use to improve energy efficiency for CWH equipment. This effort produces an initial list of all the technologies that are technologically feasible. This assessment provides the technical background and structure on which DOE bases its screening and engineering analyses.

In response to the May 2022 CWH ECS NOPR, the Joint Advocates encouraged DOE to evaluate heat pump technology as a technology option for electric storage water heaters. (The Joint Advocates, No. 29 at p. 4) The Joint Advocates and the CA IOUs both noted that commercial integrated heat pump water heaters on the market have electric resistance elements that allow them to meet required hot water demand when heat-pump-only operation would not suffice, and the CA IOUs cited such products. (The Joint Advocates, No. 29 at p. 4; CA IOUs, No. 33 at pp. 4–5) The Joint Advocates further cited that when both backup elements and the heat pump compressor are operating together in hybrid mode, this unit can achieve almost twice the heating capacity of a 12 kW commercial electric resistance water heater. (The Joint Advocates, No. 29 at p. 4) The Joint Advocates stated that they are not aware of any reason why commercial heat pump water heaters could not meet the same hot water loads as commercial electric storage water heaters. *Id.*

NYSERDA similarly urged DOE to include commercial heat pump water heaters in the analysis. They cited a recent New York Commercial Baseline Study that found that between 1 and 4 percent of commercial water heaters were classified as heat pumps across a variety of applications. Therefore, NYSERDA recommended that DOE acknowledge heat pumps in subsequent rulemakings, both as a max-tech option and as a technology across the board. (NYSERDA, No. 30, pp. 1–2)

NWPCC also commented in support of DOE including commercial heat pump water heaters as the max-tech in the analysis. NWPCC stated that the analysis is incomplete without this consideration as there are already many commercial-duty heat pump products available on the market from several manufacturers. (NWPCC, No. 21 at p. 1) They explained that heat pump water heaters are of interest to the Northwest region, as the Regional Technical Forum estimates between 20 and 30 average megawatts of energy saving potential for unitary commercial heat pump water heaters and an additional 15 megawatts of potential for consumer heat pump water heaters in commercial applications. *Id.* In contrast, A.O. Smith added that inlet water temperature will vary across regions of the country and climate zones for air-source heat pump water heaters and noted that heat-pump water heaters may require backup heating in certain scenarios. A.O. Smith also stated that an integrated heat pump water heater may not be the correct technology option for applications that require very large loads. (A.O. Smith, No. 22 at p. 6)

In response to these comments, DOE notes that, as discussed in section III.B.4 of this document, it did not consider commercial heat pump water heaters in this final rule because of the limited number of units on the market, but may analyze commercial heat pump water heaters in a future rulemaking.

Because thermal efficiency, standby loss, and UEF are the relevant performance metrics in this rulemaking, DOE did not consider technologies that have no significant effect on these metrics. However, DOE does not discourage manufacturers from using these other technologies because they might reduce annual energy consumption in the field. The following list includes the technologies that DOE did not consider because they would not significantly affect efficiency as measured by the DOE test procedure. Chapter 3 of the final rule TSD provides details and reasoning for the exclusion from further consideration of each technology option, as listed here:

- Plastic tank
- Direct vent
- Timer controls
- Intelligent and wireless controls
- Modulating combustion
- Self-cleaning.

DOE also did not consider technologies as options for increasing efficiency if they are included in baseline equipment, as determined from an assessment of units on the market. DOE's research suggests that electromechanical flue dampers and electronic ignition are technologies included in baseline equipment for commercial gas-fired storage water heaters; therefore, they were not included as technology options for that equipment class. However, electromechanical flue dampers and electronic ignition were not identified on baseline units for residential-duty gas-fired storage water heaters, and these options were, therefore, considered for increasing efficiency of residential-duty gas-fired storage water heaters. DOE also considered insulation of fittings around pipes and ports in the tank to be included in baseline equipment; therefore, such insulation was not considered as a technology option for the analysis.

The technology options that were considered for improving the energy efficiency of CWH equipment for this final rule are as follows:

- Improved insulation (including increasing jacket insulation, insulating tank bottom, advanced insulation types, and foam insulation)

- Mechanical draft (including induced draft (also known as power vent) and forced draft)

- Condensing heat exchanger (for all gas-fired equipment classes and including optimized flue geometry)

- Condensing pulse combustion

• Improved heat exchanger design (including increased surface area and increased baffling)

• Sidearm heating and two-phase thermosiphon technology

• Electronic ignition systems

• Improved heat pump water heaters (including gas absorption heat pump water heaters)

• Premix burner (including submerged combustion chamber for gas-fired storage water heaters and storage-type instantaneous water heaters)

• Electromechanical flue damper

• Modulating combustion.

Chapter 3 of the final rule TSD includes descriptions of all technology options identified for this equipment.

B. Screening Analysis

DOE uses the following 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 431.4; 10 CFR part 430, subpart C, appendix A, sections 6(c)(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.

1. Screened-Out Technologies

Technologies that pass through the screening analysis are subsequently examined in the engineering analysis for consideration in DOE's downstream cost-benefit analysis. In the May 2022 CWH ECS NOPR, DOE screened out gas absorption heat pump water heaters due to concerns about their practicability to manufacture, install, and service. In response, the Joint Advocates encouraged DOE to evaluate this technology as a potential max-tech efficiency level for commercial gas storage water heaters. The Joint Advocates explained that there appear to be gas-fired heat pump models on the market that can provide both space and water heating capabilities, and cited one such example. (The Joint Advocates, No. 29 at p. 2) The CA IOUs and NEEA also stated that DOE should evaluate gas heat pump water heaters as a max-tech level, and cited several examples. (CA IOUs, No. 33 at p. 3; NEEA, No. 35, pp. 2–3)

DOE notes that the examples cited by the Joint Advocates and the CA IOUs do not meet the input rating requirements to be considered CWH equipment by the definitions in 10 CFR 431.102. However, other examples provided by commenters do appear to meet the requirements to be considered CWH equipment, but have low maximum output water temperatures and may not be suitable for all applications. Therefore, DOE does not have adequate information at this time to determine if these products would result in adverse impacts on consumer utility. Additionally, DOE is not aware of any demonstration of this technology as being suitable for commercial applications or as being practicable to manufacture, install, and service on the scale necessary to serve the CWH equipment market at the time of the effective date of this adopted standard. Accordingly, that technology remains screened out.

Based upon a review under the above factors, DOE screened out the design options listed in Table IV.3 for the reasons provided. Chapter 4 of the final rule TSD contains additional details on the screening analysis, including a discussion of why each technology option was screened out.

Table IV.3 Summary of Screened-Out Technology Options

Excluded Technology Option	Applicable Equipment Classes*	Reasons for Exclusion				
		Technological Feasibility	Practicability to Manufacture, Install, and Service	Adverse Impacts on Product Utility	Adverse Impacts on Health or Safety	Unique-Pathway Proprietary Technology
Advanced insulation types	All storage water heaters	X	X			
Condensing pulse combustion	All gas-fired equipment classes		X			
Sidearm heating	All gas-fired storage		X			
Two-phase thermosiphon technology	All gas-fired storage		X			
Gas absorption heat pump water heaters	Gas-fired instantaneous water heaters		X			

*All mentions of storage water heaters in this column refer to both storage water heaters and storage-type instantaneous water heaters.

In this final rule, DOE concludes that none of the identified technology options are proprietary. However, in the engineering analysis, DOE included the manufacturer production costs associated with multiple designs of condensing heat exchangers used by a range of manufacturers, which represent the vast majority of the condensing gas-fired storage water heater market, to account for intellectual property rights surrounding specific designs of condensing heat exchangers.

2. Remaining Technologies

After screening out or otherwise removing from consideration certain technologies, the remaining technologies are passed through for consideration in the engineering analysis. Table IV.4 presents identified technologies for consideration in the engineering analysis. Chapter 3 of the final rule TSD contains additional details on the technology assessment and the technologies analyzed.

Table IV.4 Technology Options Considered for Engineering Analysis

Equipment	Mechanical Draft	Condensing Heat Exchanger	Increased Heat Exchanger Area, Baffling	Electronic Ignition	Premix Burner	Electro-Mechanical Flue Damper
Commercial gas-fired storage water heaters and storage-type instantaneous water heaters	X	X	X		X	
Residential-duty gas-fired storage water heaters	X	X	X	X	X	X
Gas-fired instantaneous water heaters and hot water supply boilers	X	X	X		X	

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 CWH equipment. 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 equipment, DOE considers technologies and design option combinations not eliminated by the screening analysis. For each equipment category, DOE estimates the baseline cost, as well as the incremental cost for the equipment 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 and the NIA).

1. Efficiency Analysis

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 interpolate to define "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).

For the analysis of thermal efficiency and UEF levels, DOE identified the efficiency levels for the analysis based on market data (*i.e.*, the efficiency level approach). For the analysis of standby loss levels, DOE identified efficiency levels for analysis based on market data, commonly used technology options (*e.g.*, electronic ignition), and testing data (*i.e.*, a combination of the efficiency level approach and the design option approach). DOE's selection of efficiency levels for this final rule is discussed in additional detail in section IV.C.4 of this document.

2. 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 equipment 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 ("BOM") 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 BOM 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.

For this final rule, DOE conducted the cost analysis using a combination of physical teardowns and catalog teardowns. The resulting BOMs from physical and catalog teardowns provide the basis for the manufacturer production cost ("MPC") estimates.

To account for manufacturers' non-production costs and profit margin, DOE applies a non-production cost 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 reports filed by companies that manufacturer CWH equipment, and information gathered from manufacturers as part of the analytic process for the May 2016 CWH ECS NOPR. Chapter 5 of the final rule TSD includes further detail on the engineering analysis.

In the May 2022 CWH ECS NOPR, DOE chose the physical and catalog teardown approach over the price survey approach, based upon several factors. 87 FR 30635-30636. In response to the May 2022 CWH ECS NOPR, Bradford White suggested that DOE conduct additional interviews given that previous interviews were conducted over 6 years ago, meaning the data would not have taken into account the national and international impacts of the global pandemic. (Bradford White, No. 23 at p. 8) Bradford White and Rheem both indicated interest in participating in confidential interviews to provide further feedback. (Bradford White, No. 23 at p. 8, Rheem, No. 24 at p. 1) PHCC also encouraged the DOE to revise its production cost information due to recent market conditions, stating that projections based on the value of the U.S. dollar in 2020 do not accurately capture the effects of supply chain issues and the increase in steel prices. (PHCC, No. 28 at p. 9) PHCC stated that inflationary pressures have tremendously changed prices recently. However, PHCC acknowledged that as an association, anti-trust regulations limit their ability to gather or distribute pricing information; therefore, their analysis is based on available sources such as online retailers in order to gauge current market realities. *Id*.

In response to this feedback, DOE conducted additional interviews after the publication of the May 2022 CWH ECS NOPR to better understand manufacturer's concerns regarding the proposals of the May 2022 CWH ECS NOPR and gathered additional feedback to inform its updated MPC estimates. Additionally, DOE updated all its part prices to reflect more recent data, as discussed in section IV.C.7 of this document.

The MPCs presented in this final rule take into account the feedback received from manufacturers, which DOE has found to be a valuable tool for ensuring the accuracy of its cost estimates. Without adequate safeguards, manufacturers would likely be unwilling to share information relevant to the rulemaking, which would have correspondingly negative impacts on the rulemaking process. In the present case, as is generally the case in appliance standards rulemakings, manufacturer and equipment specific data are presented in aggregate. Additionally, as discussed in more detail in section IV.C.7 of this document, prices for raw materials and purchased parts have been updated to the most recent market estimates to create the current MPCs, resulting in increased MPCs as compared to the results presented in the May 2022 CWH ECS NOPR.

3. Representative Equipment for Analysis

For the engineering analysis, DOE reviewed all CWH equipment categories analyzed in this rulemaking (see section III.B of this document for discussion of rulemaking scope) and examined each one separately. Within each equipment category, DOE analyzed the distributions of input rating and storage volume of models available on the market and held discussions with manufacturers to determine appropriate representative equipment. DOE notes that representative equipment was selected which reflects the most common capacity and/or storage volume for a given equipment category. While a single representative equipment capacity can never perfectly represent a wide range of input capacities or storage volumes, DOE reasons that analyzing a representative capacity and storage volume that was selected using manufacturer feedback is sufficiently representative of the equipment category while also allowing for a feasible analysis.

For storage water heaters, the volume of the tank is a significant factor for costs and efficiency. Water heaters with larger volumes have higher materials, labor, and shipping costs. A larger tank volume is likely to lead to a larger tank surface area, thereby increasing the standby loss of the tank (assuming other factors are held constant, *e.g.*, same insulation thickness and materials). The current standby loss standards for storage water heaters are, in part, a function of volume to account for this variation with tank size. The incremental cost of increasing insulation thickness varies as the tank volume increases, and there may be additional installation concerns for increasing the insulation thickness on larger tanks. Installation concerns are discussed in more detail in section IV.F.2.b of this final rule. DOE examined specific storage volumes for storage water heaters and storage-type instantaneous water heaters (referred to as representative storage volumes). Because DOE lacked specific information on shipments, DOE used its CWH equipment database (discussed in section IV.A.3 of this final rule) to examine the number of models at each rated storage volume to determine the representative storage volume, and also solicited feedback from manufacturers during manufacturer interviews as to which storage volumes corresponded to the most shipments. Table IV.5 shows the representative storage volumes that DOE determined best characterize each equipment category.

For all CWH equipment categories, the input capacity is also a significant factor for cost and efficiency. Water heaters with higher input capacities typically have higher materials costs and may also have higher labor and shipping costs. Gas-fired storage water heaters with higher input capacities may have additional heat exchanger length to transfer more heat. This leads to higher material costs and may require the tank to expand to compensate for the displaced volume. Gas-fired tankless water heaters, circulating water heaters, and hot water supply boilers require larger heat exchangers to transfer more heat with a higher input capacity. In the May 2022 CWH ECS NOPR, DOE examined input capacities for models in all gas-fired CWH equipment categories to determine representative input capacities. Because the gas-fired instantaneous water heaters and hot water supply boilers equipment class includes several types of equipment that is technologically disparate, DOE selected representative input capacities that would represent both tankless water heaters and circulating water heaters and hot water supply boilers within this broader equipment class. DOE did not receive any shipments data for specific input capacities, and, therefore, DOE considered the number of models at each input capacity in the database of models it compiled (based on DOE's Compliance Certification Database, the AHRI Directory, the CEC Appliance Database, and manufacturer literature), as well as feedback from manufacturer interviews in determining the appropriate representative input capacities for this final rule.

In response to the May 2022 CWH ECS NOPR, the Joint Advocates agreed that DOE's approach of using a representative capacity chosen based on discussions with manufacturers allows the analysis to be both feasible and sufficiently representative. (The Joint Advocates, No. 29 at p. 2) A.O. Smith commented that based on their analysis, the most popular size of residential-duty commercial water heater units is 75 and 100 gallon non-condensing models. (A.O. Smith, No. 22 at p. 4) DOE agrees with A.O. Smith that the most popular size of residential-duty CWH units is 75 and 100 gallons but notes that 75 gallon size is the most common size in its database. Therefore, DOE continued to use 75 gallons as the representative storage volume for residential-duty commercial water heaters in this final rule.

Bradford White questioned how DOE found similar costs for instantaneous and hot water supply boilers with storage volumes greater than or equal to 10 gallons and those with storage volumes less than 10 gallons. Bradford White stated that DOE assumed heat exchanger costs will increase as input and surface area increase; however, Bradford White suggested that this relationship changes at larger inputs where manufacturers cannot necessarily justify automating the manufacturing of heat exchangers or some part of them. They also added that combustion systems and other non-heat-exchanger costs will increase stepwise at a certain point. (Bradford White, No. 23 at p. 5)

DOE agrees that MPCs related to the combustion and heat exchange subsystems for condensing circulating water heaters and hot water supply boilers typically follows a step-like pattern as input capacities increase. DOE's research suggests that within a set input capacity range, circulating water heaters and hot water supply boilers feature many of the same components. For example, a larger-capacity condensing circulating water heater or hot water supply boiler may feature one or more heat exchangers, each of which features a separate premix burner, gas valve, and blower system. Thus, within a given range of input capacities, the MPC of the combustion and heat exchange system will not change materially until an input/efficiency limit is reached; at that point, manufacturers typically add another parallel combustion path to the system (requiring a burner, heat exchanger, blower, and associated controls) or turn to a wholly new combustion system.

As previously noted, DOE conducted this engineering analysis using a representative capacity and storage volume for each equipment category that was determined to be sufficiently representative of the category as a whole while also allowing for a feasible analysis. However, no representative storage volume was chosen for the instantaneous water heaters and hot water supply boilers equipment class because only gas-fired instantaneous water heaters and hot water supply boilers with greater than or equal to 10 gallons of storage volume have standby loss standards but amended standby loss standards for this equipment were not analyzed in this final rule (as discussed in section III.B.6 of this document). Given the similarities in thermal efficiency performance and the technologies that could be used to improve thermal efficiency of circulating water heaters and hot water supply boilers with storage volumes greater than or equal to 10 gallons and those with storage volumes less than 10 gallons, DOE concluded that a single representative input capacity would sufficiently represent this entire equipment category for the analysis of amended thermal efficiency levels.

Additionally, Barton Day Law argued that DOE's categorization of products is inappropriate in the context of the LCC analysis, claiming that some LCC inputs would be different for products within the same category. In particular, Barton Day Law noted that there is only one LCC analysis for four separate standards for residential-duty water heaters with different draw patterns. (Barton Day Law, Public Meeting Transcript, No. 13 at pp. 29–30) In response to the comments from Barton Day Law, as described in section V.A of this final rule, DOE groups various efficiency levels for each equipment class into TSLs in order to examine the combined impact that amended standards for all analyzed equipment classes would have on an industry. This approach also allows DOE to capture the effects on manufacturers of amended standards for all classes, better reflecting the burdens for manufacturers that produce equipment across several equipment classes. Additionally, DOE is only aware of residential-duty water heaters in the high draw pattern group at the time of the current analysis. Therefore, DOE's analysis used representative storage volumes and input capacities that reflect this draw pattern group but DOE then applied its findings to other draw patterns.

The representative input capacities used in the analyses for this final rule are shown in Table IV.5. The representative volume and input capacities shown in Table IV.5 are the same as those used for May 2022 CWH ECS NOPR.

Table IV.5 Representative Storage Volumes and Input Capacities

Equipment		Specifications	Representative Rated Storage Volume *gal*	Representative Input Capacity *kBtu/h*
Commercial gas-fired storage water heaters and gas-fired storage-type instantaneous water heaters*		>105 kBtu/h or >120 gal	100	199 kBtu/h
Residential-duty gas-fired storage water heaters**		≤105 kBtu/h and ≤120 gal	75	76 kBtu/h
Gas-fired instantaneous water heaters and hot water supply boilers	Tankless water heaters	<10 gal	-	250 kBtu/h
	Circulating water heaters and hot water supply boilers	All***	-	399 kBtu/h

* Any commercial gas storage water heater that does not meet the definition of a residential-duty storage water heater is a commercial gas-fired storage water heater regardless of whether it meets the specifications listed.
** To be classified as a residential-duty water heater, a commercial water heater must, if requiring electricity, use single-phase external power supply, and not be designed to heat water at temperatures greater than 180 °F. 79 FR 40542, 40586 (July 11, 2014).
*** For the engineering analysis, circulating water heaters and hot water supply boilers with storage volume <10 gallons and ≥10 gallons were analyzed in the same equipment class. Amended standby loss standards for circulating water heaters and hot water supply boilers with storage volume ≥10 gallons were not analyzed in this final rule, as discussed in section III.B.6 of this final rule. Therefore, no representative storage volume was chosen for the instantaneous water heaters and hot water supply boilers equipment class.

In the May 2022 CWH ECS NOPR, in response to commenters' concerns about the use of a representative input capacity in its analysis of circulating water heaters and hot water boilers, DOE stated that the increase in price of a purchased part used in the construction of an especially high-capacity circulating water heater or hot water supply boiler and purchased at low volumes would be offset by the many instances in which the production costs remain fixed regardless of input capacity. 87 FR 30610, 30638. Bradford White requested that DOE clarify how fixed costs would offset an increase in the cost of other purchased parts. (Bradford White, No. 23 at p. 5) In response, DOE notes that the statement was not intended to suggest that fixed costs could lead to negative cost impacts that offset higher purchased part costs. However, the increase in cost due to those specialized components that must be purchased at lower volumes is expected to be a relatively small fraction of the overall cost of the unit, and would not significantly impact the overall product cost (but would result in a small increase).

4. Efficiency Levels for Analysis

For each equipment category, DOE analyzed multiple efficiency levels and estimated manufacturer production costs at each efficiency level. The following subsections provide a description of the full efficiency level range that DOE analyzed from the baseline efficiency level to the max-tech efficiency level for each equipment category.

Baseline equipment is used as a reference point for each equipment category in the engineering analysis and the LCC and PBP analyses, which provides a starting point for analyzing potential technologies that provide energy efficiency improvements.

Generally, DOE considers "baseline" equipment to refer to a model or models having features and technologies that just meet, but do not exceed, the Federal energy conservation standard and provide basic consumer utility.

DOE conducted a survey of its CWH equipment database and manufacturers' websites to determine the highest thermal efficiency or UEF levels on the market for each equipment category.

a. Thermal Efficiency Levels

In establishing the baseline thermal efficiency levels for this analysis, DOE used the current energy conservation standards for CWH equipment to identify baseline units. The baseline thermal efficiency levels used for the analysis in this final rule are presented in Table IV.6.

Table IV.6 Baseline Thermal Efficiency Levels for CWH Equipment

Equipment	Thermal Efficiency
Commercial gas-fired storage water heaters and storage-type instantaneous water heaters	80%
Gas-fired instantaneous water heaters and hot water supply boilers	80%

For both the commercial gas-fired storage water heaters and gas-fired instantaneous water heaters and hot water supply boilers equipment categories, DOE analyzed several thermal efficiency levels and determined the manufacturing cost at each of these levels. For this final rule, DOE developed thermal efficiency levels based on a review of equipment currently available on the market. As noted previously, DOE compiled a database of CWH equipment to determine what types of equipment are currently available to consumers. For each equipment class, DOE surveyed various manufacturers' equipment offerings to identify the commonly available thermal efficiency levels. By identifying the most prevalent thermal efficiency levels in the range of available equipment and examining models at these levels, DOE established a technology path that manufacturers typically use to increase the thermal efficiency of CWH equipment.

Consistent with the approach in the May 2022 CWH ECS NOPR, in this final rule, DOE established intermediate thermal efficiency levels for each gas-fired equipment category (aside from residential-duty gas-fired storage water heaters, which as noted previously were analyzed using UEF). The intermediate thermal efficiency levels are representative of the most common efficiency levels and those that represent significant technological changes in the design of CWH equipment. For commercial gas-fired storage water heaters and for commercial gas-fired instantaneous water heaters and hot water supply boilers, DOE chose four thermal efficiency levels between the baseline and max-tech levels for analysis. DOE selected the highest thermal efficiency level identified on the market (99 percent) as the "max-tech" level for commercial gas-fired storage water heaters and storage-type instantaneous water heaters. For gas-fired instantaneous water heaters and hot water supply boilers, DOE identified hot water supply boilers with thermal efficiency levels of up to 99 percent and tankless instantaneous water heaters with thermal efficiency levels of up to 97 percent available on the market.[36] However,

[36] DOE identified two models in CCMS with thermal efficiency levels of 98 percent but could not find any manufacturer literature for those models that would indicate whether they are tankless water heaters or hot water supply boilers. Because DOE was unable to confirm the type of construction for these water heaters and because they were not among the models listed as being available on the manufacturer's website, 98 percent was not considered the max-tech level.

the tankless water heaters with thermal efficiencies of 97 percent were at a single input capacity and it is unclear whether this thermal efficiency is achievable at other input capacities. As discussed in section IV.A.2.c of this document, DOE analyzed tankless water heaters and circulating water heaters and hot water supply boilers as two separate kinds of representative equipment for this rulemaking analysis, but they are part of the same equipment class (gas-fired instantaneous water heaters and hot water supply boilers). Therefore, because DOE did not find evidence that 97 percent would be an appropriate max-tech level for tankless instantaneous water heaters that is achievable across the range of product inputs currently available, DOE analyzed 96 percent thermal efficiency as the max-tech level for the gas-fired instantaneous water heaters and hot water supply boilers equipment class. The selected thermal efficiency levels used in the current final rule analysis are shown in Table IV.7 of this document.

In response to the May 2022 CWH ECS NOPR, DOE received several comments from stakeholders about the thermal efficiency levels it analyzed. Rheem stated concerns with the inconsistent levels proposed for the different equipment classes, which can be used in the same applications. Rheem recommended that a lower condensing thermal efficiency level that does not exceed ENERGY STAR levels be applied uniformly across the four equipment classes. (Rheem, No. 24 at p. 2) Similarly, A.O. Smith stated that DOE should reconsider setting new minimum energy conservation standards for all commercial gas-fired water heaters (excepting residential-duty commercial water heaters) at 94 percent thermal efficiency or, in the alternative setting, a 95 percent thermal efficiency level across all product types, and added that either outcome will result in significant energy savings. However, A.O. Smith stated that a 94 percent thermal efficiency level would afford a broader set of product options for CWH consumers, while at the same time provide a more level playing field upon which manufacturers can compete, foster innovation, and allow for continued incentivizing of the market adoption of high-efficiency gas-fired CWH equipment. (A.O. Smith, No. 22 at pp. 2-4) AHRI requested that a 94 percent thermal efficiency be adopted if a condensing-only standard is set based on its review of market data, and noted that this efficiency aligns with the current ENERGY STAR levels and captures the main distribution of condensing models by market share. AHRI stated that its research indicates there is a misalignment between the market data and the available product data in terms of the market shares. (AHRI, No. 31 at p. 2) Rheem also argued that all commercial gas-fired storage-type instantaneous water heaters with a rated storage volume less than 100 gallons, as listed in the Compliance Certification Management System ("CCMS"), will not meet the proposed energy conservation standard of 95 percent thermal efficiency. Rheem further stated that it is unproven if the proposed efficiency level can be achieved, given the design constraints for this product size, and recommended that DOE reevaluate EL3 for gas-fired storage-type instantaneous water heaters and add a 94 percent thermal efficiency level, consistent with ENERGY STAR. (Rheem, No. 24 at p. 3) Similarly, Rheem stated that all but two hot water supply boilers with input rates above 500 kBtu/h and 200 Btu/h per gallon of storage volume will not meet the proposed energy conservation standard of 96 percent thermal efficiency, and added that given the design constraints, it is unproven that the proposed efficiency level can be achieved for these product sizes as well. *Id.* Rheem recommended that DOE reevaluate EL3 and EL4 for gas-fired hot water supply boilers with input rates above 500 kBtu/h and 200 kBtu/h per gallon of storage volume, which is consistent with Version 2.0 of the Energy Star Program Requirements Product Specification for Commercial Water Heaters. *Id.*

A.O. Smith stated that the ENERGY STAR program has been a significant driver of the CWH market's adoption of high efficiency equipment. They added that the ENERGY STAR market penetration stood at 51 percent in 2020, according to a report by ENERGY STAR. (A.O. Smith, No. 22 at p. 2, 3) Similarly, A.O. Smith added that while CWH customers continue to adopt high efficiency (*e.g.*, condensing) commercial gas-fired water heaters, the ENERGY STAR 94 percent thermal efficiency level for commercial gas-fired water heaters continues to be a catalyst. They explain that this standard still affords consumers a large range of high efficiency product options for the intended utility, which is especially important for small business owners who operate their enterprises on very small margins. In contrast, this range of options at or above 94 percent would become smaller if, as proposed, the Department sets new minimum energy conservation standards above the ENERGY STAR level. *Id.*

In response to these comments, DOE reviewed the distributions of products on the market. As initially shown in chapter 3 of the May 2022 CWH ECS NOPR TSD and updated in chapter 3 of the current final rule TSD, the market distributions show the greatest number of unique basic models within the condensing range at 96 percent for gas-fired storage water heaters and storage type-instantaneous water heaters, gas-fired tankless water heaters, and gas-fired circulating water heaters and hot water supply boilers. There are more models at this level than at either 95 or 94 percent for each product category. Although setting the standard at 94 percent would increase the potential for product differentiation at efficiency levels above the standard level, DOE anticipates that there is still room for product differentiation for both gas-fired storage water heaters (for which products above 95 percent efficiency currently exist at 96, 97, 98, and 99 percent), tankless water heaters (for which products exist at 97 percent efficiency), and circulating water heaters and hot water supply boilers (for which products exist at 97, 98, and 99 percent). Furthermore, because most condensing gas water heaters are already at or above 95 percent (for gas storage water heaters) and 96 percent (for gas-fired instantaneous water heaters) and the equipment designs are similar at 94 percent but would result in less energy savings, DOE did not find a strong justification for analyzing a 94 percent efficiency level in this final rule. Additionally, because storage water heaters and storage-type instantaneous water heaters provide different consumer utility than instantaneous water heaters other than storage-type instantaneous water heaters (*i.e.*, tankless water heaters and circulating water heaters and hot water supply boilers can provide a continuous supply of hot water on demand, while storage water heaters are often better suited to handle large initial demands for hot water, and are also more likely to have energy losses associated with hot water storage), DOE does not agree that inconsistent efficiency levels across these equipment categories will disadvantage certain markets. Therefore, DOE continued to use the same efficiency levels in this final rule as were analyzed in the May 2022 CWH ECS NOPR.

Table IV.7 Baseline, Intermediate, and Max-Tech Thermal Efficiency Levels for Representative CWH Equipment

Equipment	Thermal Efficiency Levels					
	Baseline - E_t EL0	E_t EL1	E_t EL2	E_t EL3	E_t EL4	E_t EL5*

Commercial gas-fired storage water heaters and storage-type instantaneous water heaters	80%	82%	90%	92%	95%	99%
Gas-fired instantaneous water heaters and hot water supply boilers	80%	82%	84%	92%	94%	96%

* Et EL5 is the max-tech efficiency level for commercial gas-fired storage water heaters and storage-type instantaneous water heaters, as well as for gas-fired instantaneous water heaters and hot water supply boilers.

b. Standby Loss Levels

DOE used the current energy conservation standards for standby loss to set the baseline standby loss levels. Table IV.8 shows these baseline standby loss levels for representative commercial gas-fired storage water heaters and storage-type instantaneous water heaters.

Table IV.8 Baseline Standby Loss Levels for Representative CWH Equipment

Equipment	**Representative Rated Storage Volume** *gal*	**Representative Input Capacity** *kBtu/h*	**Baseline Standby Loss Level** *Btu/h*
Commercial gas-fired storage water heaters and storage-type instantaneous water heaters	100	199	1349

Standby loss is a function of storage volume and input capacity for gas-fired and oil-fired storage water heaters, and is affected by many aspects of the design of a water heater. Additionally, standby loss is not widely reported in manufacturer literature so DOE relied on current and past data obtained from DOE's Compliance Certification Database and the AHRI Directory. There is significant variation in reported standby loss values in these databases (*e.g.*, standby loss values for commercial gas storage water heaters range from 33 percent to 100 percent of the maximum allowable standby loss standard for those units). However, most manufacturers do not disclose the presence of technology options that affect standby loss, including insulation thickness and type, and baffle design, in their publicly-available literature. Because most manufacturers do not disclose the presence of such options, DOE was unable to determine the standby loss reduction from standby-loss-reducing technology options using market-rated standby loss data.

As discussed in the May 2022 CWH ECS NOPR, for all commercial gas-fired storage water heater levels, the only standby loss reduction analyzed corresponds to the inherent standby loss reduction from increasing thermal efficiency. (DOE notes that for non-condensing residential-duty gas-fired storage water heaters, an electromechanical flue damper and electronic ignition were considered which would improve UEF by reducing standby losses. This is discussed further in section IV.C.4.c of this document.) DOE did not analyze improved tank insulation as a technology option for reducing standby loss in this final rule because such insulation improvements would not be a viable standby loss reducing option for all models on the market.

Standby loss is measured in the test procedure predominantly as a function of the fuel used to heat the stored water during the standby loss test, with a small contribution of electric power consumption (if the unit requires a power supply). Because standby loss is calculated using the fuel consumed during the test to maintain the water temperature, the standby loss is dependent on the thermal efficiency of the water heater. DOE used data from independent testing of CWH equipment at a third-party laboratory to estimate the fraction of standby loss that can be attributed to fuel consumption or electric power consumption. DOE then scaled down (*i.e.*, made more stringent) the portion of the standby loss attributable to fuel consumption as thermal efficiency increased to estimate the inherent improvement in standby loss associated with increasing thermal efficiency. Chapter 5 of the final rule TSD explains these calculations, and the interdependence of thermal efficiency and standby loss are explained in more detail.

Standby loss levels for each equipment category are shown in the following sections in terms of Btu/h for the representative equipment. However, to analyze potential amendments to the current Federal standard, factors ("standby loss reduction factors") were developed to multiply by the current maximum standby loss equation for each equipment class, based on the ratio of standby loss at each efficiency level to the current standby loss standard. The translation from standby loss values to maximum standby loss equations is described in further detail in section IV.C.4 of this final rule.

In response to the May 2022 CWH ECS NOPR, Bock indicated support for DOE to set the reduction in standby loss to a level inherent with the proposed thermal efficiency. (Bock, No. 20 at p. 1) Rheem also commented in support of DOE's use of one standby loss level for each efficiency level, but stated that DOE did not clarify which technologies were used at the baseline and how these would be scaled across the various equipment sizes for any of the four equipment classes analyzed. (Rheem, No. 24 at p. 2)

Bradford White requested that DOE reevaluate their assumptions that only changes in thermal efficiency will impact the standby loss level achieved. Bradford White stated that the relationship between standby loss and thermal efficiency can be impacted by the difference between the ambient and average tank temperatures during the test and by the time or total duration of the test, which is a function of the water heater's differential (*i.e.*, the temperature below the setpoint where the control will call for heat). (Bradford White, No. 23 at p. 9) Additionally, Bradford White raised concerns with the limited number of units tested to develop the standby loss reduction factors for commercial gas storage water heaters. Bradford White also noted that DOE did not elaborate on what type of heat exchangers were in the products that were evaluated, which would impact the observed results. For example, the commenter explained that a multi-pass heat exchanger is more likely to have greater standby loss as compared to a coiled heat exchanger that is only a single pass. Bradford White recommended that DOE analyze a greater number of units, as well as account for the types of heat exchangers when further refining the standby loss reduction factors. (Bradford White, No. 23 at p. 3)

As discussed in Chapter 5 of the TSD accompanying this final rule, DOE notes that it conducted testing prior to the withdrawn May 2016 CWH ECS NOPR to estimate the fraction of standby loss that can be attributed to fuel consumption or electric power consumption, and this fraction does not necessarily depend on the overall level of standby loss associated with each unit. Further, the units tested incorporated both multi-pass and coiled heat exchangers. Additionally, DOE's research regarding rated standby loss values showed that the majority of models at a given thermal efficiency level already meet the standby loss level associated with the standby loss reduction factor being applied for that level. In addition, because the majority of models on the market that meet each thermal efficiency level being analyzed also meet the corresponding standby loss level, further validating the standby loss levels by testing models on the market or by building water heater prototypes is not necessary and was not done for this final rule.

Table IV.9 presents the examined standby loss levels in this final rule for commercial gas-fired storage water heaters and storage-type instantaneous water heaters (other than residential-duty gas-fired storage water heaters, which are addressed in the next section). As discussed, these levels reflect only the reduction in standby loss that is achieved by increasing thermal efficiency.

Table IV.9 Standby Loss Levels for Commercial Gas-Fired Storage Water Heaters and Storage-Type Instantaneous Water Heaters, 100 Gallon Rated Storage Volume, 199,000 Btu/h Input Capacity

Thermal Efficiency Level	Thermal Efficiency	Standby Loss *Btu/h*
E_t EL0	80%	1349
E_t EL1	82%	1316
E_t EL2	90%	1223
E_t EL3	92%	1197
E_t EL4	95%	1160
E_t EL5	99%	1115

c. Uniform Energy Efficiency Levels

DOE conducted all analyses of potential amended standards for residential-duty commercial water heaters in this document in terms of UEF to reflect the current test procedure and metric.

UEF standards are draw pattern-specific (*i.e.*, there are separate standards for very small, low, medium, and high draw patterns) and are expressed by an equation as a function of the stored water volume. DOE analyzed increased standards in terms of increases to the constant term of the UEF equations and did not consider changes to the slopes of the volume-dependent term. Based on a review of the rated UEF and storage volume for products currently on the market, DOE determined that the existing slopes of the equations are representative of the relationship between UEF and stored volume across the range of efficiency levels, and thus, DOE did not find justification to consider varying the slope. Additionally, because all residential-duty gas-fired storage water heaters on the market are in the high draw pattern, the analysis was done for the high draw pattern and the same step increase are applied to all other residential-duty gas-fired storage water heater draw patterns. For residential-duty gas-fired storage water heaters, DOE chose four UEF levels between the baseline and max-tech levels for analysis.

To determine the max-tech level, DOE analyzed the difference between UEF ratings of residential-duty gas-fired storage water heaters in its database (see section IV.A.3 of this document) and the minimum UEF allowed for each model based on their rated volumes. The maximum step increase (rounded to the nearest hundredth) was 0.35. However, this level was only achieved at a single storage volume and has not been demonstrated as being achievable across a range of storage volumes. As a result, DOE considered the max-tech step increase to be 0.34, a level that has been demonstrated achievable by residential-duty gas-fired storage water heaters at a range of volumes.

In response to the May 2022 CWH ECS NOPR, A.O. Smith stated that DOE's proposed condensing levels (including near max-tech (EL5) for the high draw pattern) for residential-duty gas-fired storage water heaters are disconnected from the current marketplace for this product category and may have the unintended consequence of severely restricting product availability, which will increase costs to consumers for this product type. A.O. Smith stated that manufacturers of residential-duty water heaters made capital investments and design improvements to this product class to meet the current ENERGY STAR 4.0 specification (*e.g.*, UEF ≥ 0.80) and will need to potentially make additional investments in this product class given the ENERGY STAR program's recent publication of its final residential water heater version 5.0 specification, which sets a minimum of 0.86 UEF value for gas fired RDC products effective April 28, 2023. A.O. Smith recommended that the appropriateness of setting a minimum energy conservation standard at the condensing EL4 level for gas-fired residential-duty commercial water heaters be reconsidered, and suggested that the UEF standard for this equipment in the high draw pattern be calculated as 0.9297- (0.0016 x V_r). (A.O. Smith, No. 22 at pp. 4–5)

However, as noted previously, DOE has found that the existing slopes of the equations are representative of the relationship between UEF and stored volume across the range of efficiency levels. A.O. Smith did not provide an explanation of why a slope of 0.0016 is more appropriate than 0.0009, and thus, DOE did not find justification to consider varying the slope. Additionally, the impacts of each EL are considered in DOE's subsequent analyses and discussed in detail in section V of this final rule. However, DOE notes that, for each affected equipment class, existing equipment across a broad range of storage volumes and input capacities meets or exceeds the minimum efficiency levels adopted in this final rule. DOE does not agree that consumer choice will be restricted as a result of the revised energy conservation standards. Additionally, as discussed in section V.C, DOE has concluded that the energy conservation standards adopted in this final rule are economically justified.

The four intermediate UEF levels are representative of common efficiency levels and those that represent significant technological changes in the design of CWH equipment. Table IV.10 shows the examined UEF levels in this final rule for residential-duty gas-fired storage water heaters in terms of the incremental step increase and the resulting equation for high draw pattern models.

Table IV.10 Baseline, Intermediate, and Max-Tech UEF Levels for Residential-Duty Gas-Fired Storage Water Heaters

UEF Level	Incremental Step Increase	UEF (High Draw Pattern)*
EL0 – Baseline	0	0.6597 – (0.0009 x V_r)
EL1	0.02	0.6797 – (0.0009 x V_r)
EL2	0.09	0.7497 – (0.0009 x V_r)
EL3	0.18	0.8397 – (0.0009 x V_r)
EL4	0.27	0.9297 – (0.0009 x V_r)
EL5	0.34	0.9997 – (0.0009 x V_r)

* UEF standards vary based on the test procedure draw pattern that is used to determine the UEF rating. For simplicity and because all residential-duty gas-fired storage water heaters on the market are in the high draw pattern, only the high draw pattern efficiency levels are shown.

5. Standby Loss Reduction Factors

As part of the engineering analysis for commercial gas-fired storage water heaters, DOE reviewed the maximum standby loss equations that define the existing Federal energy conservation standards for gas-fired storage water heaters. The equations allow DOE to expand the analysis on the representative rated input capacity and storage volume to the full range of values covered under the existing Federal energy conservation standards.

DOE uses equations to characterize the relationship between rated input capacity, rated storage volume, and standby loss. The equations allow DOE to account for the increases in standby loss as input capacity and tank volume increase. As the tank storage volume increases, the tank surface area increases, resulting in higher jacket losses. As the input capacity increases, the surface area of flue tubes may increase, thereby providing additional area for standby heat loss through the flue tubes. The current equations show that for gas-fired storage water heaters, the allowable standby loss increases as the rated storage volume and input rating increase. The current form of the standby loss standard (in Btu/h) for commercial gas-fired and oil-fired water heaters is shown in the multivariable equation below, depending upon both rated input (Q, Btu/h) and rated storage volume (V_r, gal).

$$SL = \frac{Q}{800} + 110\sqrt{V_r}$$

Eq. 1

In order to consider amended standby loss standards for commercial gas-fired storage water heaters, DOE needed to revise the current standby loss standard equation to correspond to the decreased standby loss value, in Btu/h, determined for the representative capacity.

DOE analyzed more-stringent standby loss standards by multiplying the current maximum standby loss equation by reduction factors. The use of reduction factors maintains the structure of the current maximum standby loss equation and does not change the dependence of maximum standby loss on rated input and rated storage volume, but still allows DOE to consider increased stringency for standby loss standards. The standby loss reduction factor is calculated by dividing each standby loss level (in

Btu/h) by the current standby loss standard (in Btu/h) for the representative input capacity and storage volume.

Table IV.11 shows the standby loss reduction factors determined in this final rule for commercial gas-fired storage water heaters for each thermal efficiency level. As discussed in section IV.C.4.b of this final rule, the standby loss reductions associated with commercial gas-fired storage water heaters result from increased thermal efficiency. Chapter 5 of the final rule TSD includes more detail on the calculation of the standby loss reduction factor.

Table IV.11 Standby Loss Reduction Factors for Commercial Gas-Fired Storage Water Heaters

Thermal Efficiency Level	Thermal Efficiency	Standby Loss Reduction Factor
E_t EL0	80%	1.00
E_t EL1	82%	0.98
E_t EL2	90%	0.91
E_t EL3	92%	0.89
E_t EL4	95%	0.86
E_t EL5	99%	0.83

6. Teardown Analysis

After selecting a representative input capacity and representative storage volume (for storage water heaters) for each equipment category, DOE selected equipment near both the representative values and the selected efficiency levels for its teardown analysis. DOE gathered information from these teardowns to create detailed BOMs that included all components and processes used to manufacture the equipment. For the analysis of residential-duty gas-fired storage water heaters DOE identified the UEF ratings of previously torn-down models, wherever possible, and used information from those existing teardowns to inform its analyses. To assemble the BOMs and to calculate the MPCs of CWH equipment, DOE disassembled multiple units into their base components and estimated the materials, processes, and labor required for the manufacture of each individual component, a process known as a "physical teardown." Using the data gathered from the physical teardowns, DOE characterized each component according to its weight, dimensions, material, quantity, and the manufacturing processes used to fabricate and assemble it.

DOE also used a supplementary method called a "catalog teardown," which examines published manufacturer catalogs and supplementary component data to allow DOE to estimate the major differences between equipment that was physically disassembled and similar equipment that was not. For catalog teardowns, DOE gathered product data such as dimensions, weight, and design features from publicly-available information (*e.g.*, manufacturer catalogs and manufacturer websites). DOE also obtained information and data not typically found in catalogs, such as fan motor details or assembly details, from physical teardowns of similar equipment or through estimates based on industry knowledge. The teardown analysis performed for the withdrawn May 2016 CWH ECS NOPR used data from 11 physical teardowns and 22 catalog teardowns to inform development of cost estimates for CWH equipment. In the current final rule analysis, DOE included results from 11 additional physical teardowns of water heaters and hot water supply boilers. These additional physical teardowns replaced several of the virtual and physical teardowns conducted for the 2016 NOPR analysis to ensure that the MPC estimates better reflect designs of models on the market by including physical teardowns of models from additional manufacturers at numerous efficiency levels. Chapter 5 of the final rule TSD provides further detail on the CWH equipment units that were torn down.

The teardown analysis allowed DOE to identify the technologies that manufacturers typically incorporate into their equipment, along with the efficiency levels associated with each technology or combination of technologies. As noted previously, the end result of each teardown is a structured BOM, which DOE developed for each of the physical and catalog teardowns. The BOMs incorporate all materials, components, and fasteners (classified as either raw materials or purchased parts and assemblies) and characterize the materials and components by weight, manufacturing processes used, dimensions, material, and quantity. The BOMs from the teardown analysis were then used to calculate the MPCs for each type of equipment that was torn down. The MPCs resulting from the teardowns were then used to develop an industry average MPC for each efficiency level and equipment category analyzed. Chapter 5 of the final rule TSD provides more details on BOMs and how they were used in determining the manufacturing cost estimates.

During the manufacturer interviews conducted prior to the withdrawn May 2016 CWH ECS NOPR as well as in advance of this final rule, DOE requested feedback on its engineering analysis. DOE used the information it gathered from those interviews, along with the information obtained through the teardown analysis, to refine the assumptions and data used to develop MPCs. Chapter 5 of the final rule TSD provides additional details on the teardown process.

During the teardown process, DOE gained insight into the typical technology options manufacturers use to reach specific efficiency levels. DOE also determined the efficiency levels at which manufacturers tend to make major technological design changes. Table IV.12 through Table IV.15 show the major technology options DOE observed and analyzed for each efficiency level and equipment category. DOE notes that in equipment above the baseline, and sometimes even at the baseline efficiency, additional features and functionalities that do not impact efficiency are often used to address non-efficiency-related consumer demands (*e.g.*, related to comfort or noise when operating). DOE did not include the additional costs for options such as advanced building communication and control systems that are included in many of the high-efficiency models currently on the market, as they do not improve efficiency but do add cost to the model. In other words, DOE assumed the same level of non-efficiency related features and functionality at all efficiency levels. Chapter 5 of the final rule TSD includes further detail on the exclusion of costs for non-efficiency-related features from DOE's MPC estimates.

Table IV.12 Technologies Identified at Each Thermal Efficiency Level for Commercial Gas-Fired Storage Water Heaters

Thermal Efficiency Level	Thermal Efficiency	Design Changes*
E_t EL0	80%	-
E_t EL1	82%	Increased heat exchanger area
E_t EL2	90%	Condensing heat exchanger, forced draft blower, premix burner
E_t EL3	92%	Condensing heat exchanger, forced draft blower, premix burner, increased heat exchanger surface area
E_t EL4	95%	Condensing heat exchanger, forced draft blower, premix burner, increased heat exchanger surface area
E_t EL5	99%	Condensing heat exchanger, forced draft blower, premix burner, increased heat exchanger surface area

* The condensing heat exchanger surface area incrementally increases at each EL from E_t EL2 to E_t EL5.

Table IV.13 Technologies Identified at Each Thermal Efficiency Level for Residential-Duty Gas-Fired Storage Water Heaters

UEF Level	UEF (High Draw Pattern)*	Design Changes**
EL0 – Baseline	0.6597 – (0.0009 x V_r)	-
EL1	0.6797 – (0.0009 x V_r)	Increased heat exchanger area
EL2	0.7497 – (0.0009 x V_r)	Electronic ignition, electromechanical flue damper or power venting; increased heat exchanger area
EL3	0.8397 – (0.0009 x V_r)	Electronic ignition; condensing heat exchanger; power venting
EL4	0.9297 – (0.0009 x V_r)	Electronic ignition; condensing heat exchanger; power venting; premix burner; increased heat exchanger area
EL5	0.9997 – (0.0009 x V_r)	Electronic ignition; condensing heat exchanger; power venting; premix burner; increased heat exchanger area

* UEF standards vary based on the test procedure draw pattern that is used to determine the UEF rating. For simplicity and because all residential-duty gas-fired storage water heaters on the market are in the high draw pattern, only the high draw pattern efficiency levels are shown.
** The condensing heat exchanger surface area incrementally increases at each EL from EL3 to EL5.

Table IV.14 Technologies Identified at Each Thermal Efficiency Level for Gas-Fired Tankless Water Heaters

Thermal Efficiency Level	Thermal Efficiency	Design Changes*
E_t EL0	80%	-
E_t EL1	82%	Increased heat exchanger area
E_t EL2	84%	Increased heat exchanger area
E_t EL3	92%	Secondary condensing heat exchanger
E_t EL4	94%	Secondary condensing heat exchanger, increased heat exchanger surface area
E_t EL5	96%	Secondary condensing heat exchanger, increased heat exchanger surface area

* The heat exchanger surface area incrementally increases at each EL from E_t EL0 to E_t EL2 and from E_t EL3 to E_t EL5.

Table IV.15 Technologies Identified at Each Thermal Efficiency Level for Gas-Fired Circulating Water Heaters and Hot Water Supply Boilers

Thermal Efficiency Level	Thermal Efficiency	Design Changes*
E_t EL0	80%	-
E_t EL1	82%	Increased heat exchanger area
E_t EL2	84%	Increased heat exchanger area, induced draft blower
E_t EL3	92%	Condensing heat exchanger, forced draft blower, premix burner
E_t EL4	94%	Condensing heat exchanger, forced draft blower, premix burner, increased heat exchanger surface area
E_t EL5	96%	Condensing heat exchanger, forced draft blower, premix burner, increased heat exchanger surface area

* The heat exchanger surface area incrementally increases at each EL from E_t EL0 to E_t EL2 and from E_t EL3 to E_t EL5.

Rheem expressed doubt as to whether achieving 82 percent thermal efficiency is possible across the entire range of input rates and storage volumes without the addition of power venting technology. Rheem suggested that power venting technology should be included in the analysis at baseline and 82 percent thermal efficiency levels to reflect the regions requiring ultra-low NO_X CWHs. (Rheem, No. 24 at p. 2) However, DOE has identified multiple non-condensing ultra-low NO_X units that do not include power venting, which span a range of volumes and capacities. Therefore, contrary to Rheem's assertion, DOE does not expect that power venting would be necessary to achieve ultra-low NO_X operation and did not include a power vent for those levels.

Additionally, in response to the May 2022 CWH ECS NOPR, Bradford White commented that they disagree with DOE's assumption that unsophisticated controls can be used in condensing systems, stating that the controls need to be able to drive a blower, typically at different fan speeds, and provide diagnostics capability in order to provide the same reliability as non-condensing systems. Additionally, Bradford White stated that they disagree with the assumption that an increase in thermal efficiency would not affect heat loss because, they said, an increase in heat exchanger surface area will necessitate an increase in overall tank size to make up for lost storage volume and would likely lead to an increase in penetrations to the tank. (Bradford White, No. 23 at p. 2) Bradford White also noted that more sophisticated controls, a blower, different combustion components, and additional anodes are required to achieve condensing levels, and ensure a similar lifetime as non-condensing systems. (Bradford White, No. 23 at p. 5) Bradford White stated that there are some features in condensing water heaters that should have been included in DOE's cost analysis because these are necessary features to ensure that the product has comparable reliability to non-condensing water heaters, especially if condensing water heaters are assumed to have the same lifetime as non-condensing water heaters. *Id.*

As noted in the May 2022 CWH ECS NOPR, many condensing gas-fired storage water heaters currently on the market are often marketed as premium products and include non-efficiency-related features. Some of these features, such as built-in diagnostics and run history information, may require user interfaces, but a user interface is not necessary for operation of a condensing gas-fired storage water heater. DOE research suggests that condensing appliances may feature as little as a push button and several light-emitting diodes on the control board to communicate the status of the unit, error codes, and so on. Some condensing models on the market also include modulating burners and gas valves, which do require more sophisticated controls. However, modulation is not required to achieve condensing operation for gas-fired storage water heaters and does not affect efficiency as measured by DOE's test procedure. Many condensing gas-fired storage water heaters currently on the market do not include modulating combustion systems or the corresponding more sophisticated controls. While a condensing combustion assembly (comprising a gas valve, blower, and premix burner) may require calibration by the manufacturer (the costs for which DOE accounts in its development of cost estimates), DOE does not believe that a technician would need a user interface included within the water heater in order to be able to successfully diagnose and service a gas-fired storage water heater with a non-modulating combustion assembly. In order to accurately assess the costs of adopting a more-stringent standard, DOE only considers costs of components that are necessary for models to achieve each efficiency level as measured by DOE's test procedure. 87 FR 30610, 30647. In response to Bradford White's assertion that increased thermal efficiency levels would necessitate increased storage volumes, DOE notes that its analysis was conducted for a fixed storage volume and DOE did account for slight adjustments to tank dimensions in its analysis of different efficiency levels.

Therefore, DOE continued to not include the costs of features such as modulation and more sophisticated controls in its costs for high-efficiency products. However, for the final rule analysis, DOE included powered anode rods in its cost models for some condensing gas-fired storage water heaters, in response to manufacturer feedback during interviews that these components may be necessary due to space constraints. In the May 2022 CWH ECS NOPR, DOE stated that the welds inside a storage water heater are typically the primary source of concern for corrosion inside a storage water heater. Further, DOE noted that a condensing gas-fired storage water heater with a multi-pass heat exchanger design[37] will typically have more flue pipes and, therefore, more welds (joining the flue pipe and tank top or bottom) than would a non-condensing gas-fired storage water heater. To account for the fact that condensing gas-fired storage water heaters may require an additional anode rod to compensate for the additional welds, for the May 2022 CWH ECS NOPR analysis, DOE included the costs of an additional anode rod for residential-duty and commercial gas-fired storage water heaters with a multi-pass condensing heat exchanger design. 87 FR 30610, 30647. Manufacturer feedback during interviews conducted after the May 2022 CWH ECS NOPR suggested that in some cases adding additional (unpowered) anode rods is impractical due to internal geometry and therefore powered anode rods are required. DOE therefore included the additional costs for powered anode rods and associated controls for a subset of condensing gas-fired storage water heaters. Chapter 5 of the final rule TSD includes further detail on the

[37] In a multi-pass condensing heat exchanger design, the flue gases are forced through flue tubes that span the length of the tank multiple times. Typically, the flue gases are re-directed back through the tank via return plenums located above and below the tank.

exclusion of costs for non-efficiency-related features from DOE's MPC estimates and on the assumptions relating to anode rods.

In addition, Bradford White disagreed with DOE's assumption that a blower on top of a heat exchanger prevents hot air from escaping out of the flue like a flue damper. They stated that based on their testing and experience, a blower reduces standby loss but does not altogether prevent it as a damper would. (Bradford White, No. 23 at p. 2) In response, DOE notes that there are several residential-duty gas storage water heaters on the market that meet or exceed the efficiency of EL2 and include a blower but do not include a flue damper. Therefore, based on its review of the market, DOE expects that either technology option can be used to meet that efficiency level.

Additionally, for the May 2022 CWH ECS NOPR, DOE estimated that 20 percent of commercial gas-fired storage water heater shipments are manufactured with ASME construction, based on feedback from manufacturer interviews. For this share of the market, DOE applied a multiplier of 1.2 to the MPC to account for the various costs associated with ASME construction (*e.g.*, materials, labor, testing). 87 FR 30610, 30648. Bradford White commented in support of DOE's adjustment of its MPC estimates for commercial gas-fired storage water heaters for this final rule to account for the costs of American Society of Mechanical Engineers ("ASME") construction. (Bradford White, No. 23 at p. 5) Chapter 5 of the final rule TSD includes additional details on DOE's analysis of ASME construction for commercial gas-fired storage water heaters.

7. Manufacturing Production Costs

After calculating the cost estimates for all the components in each torn-down unit, DOE totaled the cost of materials, labor, depreciation, and direct overhead used to manufacture each type of equipment in order to calculate the MPC. DOE used the results of the teardowns on a market-share weighted average basis to determine the industry average cost increase to move from one efficiency level to the next. DOE reports the MPCs in aggregated form to maintain confidentiality of sensitive component data. DOE obtained input from manufacturers during the manufacturer interview process on the MPC estimates and assumptions.

DOE estimated the MPC at each efficiency level considered for representative equipment of each equipment category. DOE also calculated the percentages attributable to each element of total production costs (*i.e.*, materials, labor, depreciation, and overhead). These percentages are used to validate the assumptions by comparing them to manufacturers' actual financial data published in annual reports, along with feedback obtained from manufacturers during interviews. Chapter 5 of the final rule TSD contains additional details on how DOE developed the MPCs and related results.

In response to the May 2022 CWH ECS NOPR, DOE received multiple comments regarding its MPC estimates. Rheem commented that the MPC estimates scaled from the May 2016 CWH ECS NOPR do not accurately reflect material supply chain issues and inflationary cost increases. (Rheem, No. 24 at p. 2) Rheem asserted that the MPCs presented in Table 5.12.2 of the May 2022 CWH ECS NOPR TSD are significantly underestimated and similarly stated that the MPCs in Table 5.12.4 of the

May 2022 CWH ECS NOPR TSD are also significantly underestimated across all efficiency levels.[38] Specifically, they stated that in Table 5.12.2 of the May 2022 CWH ECS NOPR TSD, the incremental cost to shift from non-condensing to condensing, EL2 to EL3, is especially significant, though the non-condensing MPC estimates are more reasonable. (Rheem, No. 24 at p. 4) Rheem added that the incremental cost from non-condensing to condensing in Table 5.12.4 of the May 2022 CWH ECS NOPR TSD, while low, is a reasonably accurate incremental increase. *Id*. Along the same lines, Rheem stated that the MPCs for all efficiency levels of commercial gas-fired storage water heaters are also significantly understated, and that the incremental cost between EL1 and EL2 should be much greater than $106. Rheem commented that DOE is not fully accounting for the differences between consumer (residential-duty) and commercial water heaters. *Id*. at p. 4. (Rheem, No. 24 at p. 4) Bradford White also stated that the increase in cost between EL1 and EL2 should be greater than $106 and cited the number of construction changes and components required to achieve condensing levels as rationale to support their assertion. (Bradford White, No. 23 at p. 5)

Bock Water Heaters stated that in Table IV.16 of the May 2022 CWH ECS NOPR,[39] the difference in cost between EL0 and condensing levels, specifically EL4, for commercial gas-fired storage water heaters is substantially understated. Bock Water Heaters also stated that the magnitude of the MPC estimates in Table IV.16 in the May

[38] Table 5.12.2 presents DOE's estimated MPC, MSP, and shipping costs for residential-duty gas-fired storage water heaters at the representative rated storage volume of 75 gallons and representative input capacity of 76,000 Btu/h. Table 5.12.4 presents DOE's estimated MPC, MSP, and shipping costs for gas-fired circulating water heaters and hot water supply boilers at the representative input capacity of 399,000 Btu/h.

[39] Table IV.16 presents the MPC for commercial gas fires storage water heaters at the representative rated storage volume of 100 gallons and representative input capacity of 199,000 Btu/h.

2022 CWH ECS NOPR were not representative of actual costs incurred by small manufacturers such as themselves. The commenter noted that although economies of scale will drive differences in MPC by manufacturer, the values presented in Table IV.16 of the May 2022 CWH ECS NOPR should be closer to an average representation of all manufacturers. (Bock Water Heaters, No. 20 at pp. 1-2)

A.O. Smith stated that there is a meaningful delta (*e.g.*, about 40 percent) in DOE's estimated MPCs for the referenced 75 gallon product category versus what manufacturers submitted to the Department's contractor during confidential interviews. (A.O. Smith, No. 22 at p. 4)

PHCC commented that DOE's analysis has undervalued product costs at higher efficiency levels by omitting costs for additional features. They feel that the net effect is a significant cost increase relative to the NOPR projections even if market pressures and streamlining of inventories leads to savings and lowers prices. (PHCC, No. 28 at p. 9) PHCC generally noted that they believe there are gaps in the economic analysis. (PHCC, No. 28 at p. 2) PHCC stated that according to a nationally known online plumbing wholesaler, one model of non-condensing 100-gallon 199,000 Btu water heater would sell for about $8,100 (for product costs only) and the condensing version of that capacity would sell for about $10,000. (PHCC, No. 28 at p. 10)

A.O. Smith expressed concern about the impacts of these inaccurate MPCs on the downstream analysis. (A.O. Smith, No. 22 at p. 4) Bock Water Heaters and Rheem expressed similar concern, and specifically noted that the understated MPC values may have affected the accuracy of the LCC analysis and PBP analysis. (Bock Water Heaters, No. 20 at pp. 1-2; Rheem, No. 24 at p. 1)

Bock Water Heaters, AHRI, Rheem, and PHCC also encouraged DOE to re-engage with manufacturers to verify its product cost information. (Bock Water Heaters, No. 20 at p. 2; AHRI, No. 31 at p. 5; Rheem, No. 24 at p. 1; PHCC, No. 28 at p. 10) Specifically, AHRI requested that additional manufacturer interviews be conducted relating to manufacturing processes, costs, and capacity constraints as well as impacts on small manufacturers and shipping costs. (AHRI, No. 31 at p. 5) Bradford White requested that DOE explain how it determined that improved economies of scale will offset other costs, noting that these other costs must be accounted for, will ideally be recovered, and will result from a more stringent standard (*e.g.*, capital conversion costs). (Bradford White, No. 23 at p. 6)

In response to these comments, DOE notes that it developed its MPC estimates based on teardowns of CWH equipment from a variety of manufacturers. DOE conducted several rounds of manufacturer interviews and follow-up interviews with all CWH equipment manufacturers that responded to DOE's requests for interviews, including additional interviews conducted after the publication of the May 2022 CWH ECS NOPR. As part of the manufacturer interview process, DOE sought feedback on its MPC estimates, as well as feedback on specific component, material, labor, and assembly costs. DOE's methodology for developing MPC estimates involves estimating the material, labor, depreciation, and overhead costs for every part and assembly within a unit. DOE agrees that prices for many parts have increased in recent years. Component costs were also updated for this final rule analysis, to reflect recent fluctuations and trends in cost values.

Conducting the analysis to this level of detail allows DOE to estimate the cost of units that were not physically torn down, or to estimate the costs of making slight design changes such as adding an inch of insulation or increasing heat exchanger size. In the interviews conducted prior to the withdrawn May 2016 CWH ECS NOPR, DOE presented manufacturers with MPC estimates broken down by each assembly (*e.g.*, burner and gas valve, heat exchanger, controls) of the water heater, or even a BOM of a torn-down unit from that manufacturer for specific feedback on the estimated costs for every single part within the torn-down unit.

Regarding the incremental costs between non-condensing and condensing levels, DOE first notes that the incremental MPC estimate reflects the additional components needed to build a condensing product while subtracting components that are either replaced or obviated. For example, condensing gas-fired storage water heaters require a mechanical draft combustion system, while baseline non-condensing models do not. Conversely, baseline non-condensing commercial water heaters typically include an electromechanical flue damper, while condensing models do not because they have a mechanical-draft combustion system that obviates the need for a flue damper.

Additionally, as discussed in section IV.C.6 of this final rule, DOE standardized non-efficiency-related features across all efficiency levels. This may cause DOE's incremental MPC estimates to seem lower than that of equipment currently on the market, because in many cases condensing equipment is currently marketed as a premium product and includes features (*e.g.*, advanced controls or modulating gas valves) that are not necessary for condensing operation and do not affect efficiency as measured by DOE's test procedure. However, as discussed in section IV.C.6, based on feedback received during manufacturer interviews, DOE did update its cost models for a subset of condensing gas-fired storage water heaters to include powered anode rods. The updates to part prices as well as the other changes that DOE implemented increased the cost delta between noncondensing and condensing gas-fired storage water heaters from $106.41 to $120.65. Chapter 5 of the final rule TSD includes further detail on the exclusion of costs for non-efficiency-related features from DOE's MPC estimates.

The MPC estimates presented in this final rule and chapter 5 of the final rule TSD are market-shared weighted average MPCs, which will not necessarily be representative for every design pathway used by every manufacturer (*i.e.*, they reflect the industry average cost). DOE research suggests that the absolute and incremental MPCs between baseline and condensing levels are higher for some manufacturers than others. Therefore, DOE included multiple design pathways that are used by a range of manufacturers and that represent the vast majority of models on the market in the market-share weighted average cost estimates, both in absolute as well as incremental terms. Similarly, in response to comments about its production volumes, DOE notes that its model incorporates different production volumes (which are also informed by manufacturer feedback) when developing the production cost estimates from different manufacturers. DOE then combined the resulting production cost estimates from different manufacturers into its market-share weighted average cost estimates.

Finally, in response to PHCC's comment suggesting that publicly-available costs are much higher than DOE's MPCs, DOE notes that these MPCs do not account for any subsequent markups, such as from manufacturers, wholesalers, or mechanical contractors, that will increase the price for end consumers. Manufacturer markups are discussed in more detail in section IV.C.8 and other markups are discussed in section IV.D.

For the reasons summarized previously, DOE has concluded that its methodology for developing MPC estimates presented in the May 2022 CWH ECS NOPR is sound and has maintained a similar methodology for this final rule. Additionally, as discussed, DOE understands that many component prices have been increasing recently and DOE revised inputs to the development of MPC estimates based on updated information (including pricing for raw materials and purchased parts) received from manufacturers after the May 2022 CWH ECS NOPR. These changes resulted in increased MPCs. Depending on the specific product categories and efficiency levels, these changes increased MPCs by between 9 percent and 27 percent as compared to the May 2022 CWH ECS NOPR. Because prices continue to fluctuate, and the analyses for this final rule are in 2022$ (thus reflecting average values in 2022), there may continue to be discrepancies between the MPCs and the current prices at the time of publication. Using 5-year averages for raw metals (as discussed in chapter 5 of this final rule TSD) is also expected to smooth out spikes in raw metal costs. Table IV.16, Table IV.17, and Table IV.18 of this document show the MPC for each combination of thermal efficiency and standby loss levels for each equipment category.

Table IV.16 Manufacturer Production Costs for Commercial Gas-Fired Storage Water Heaters, 100-Gallon Rated Storage Volume, 199,000 Btu/h Input Capacity

Thermal Efficiency Level	Thermal Efficiency	MPC *2022$*
E_t EL0	80%	$1,453.78
E_t EL1	82%	$1,489.43
E_t EL2	90%	$1,610.08
E_t EL3	92%	$1,629.39
E_t EL4	95%	$1,666.24
E_t EL5	99%	$1,733.86

Table IV.17 Manufacturer Production Costs for Residential-Duty Gas-Fired Storage Water Heaters, 75-Gallon Rated Storage Volume, 76,000 Btu/h Input Capacity

Efficiency Level	UEF (High Draw Pattern)*	MPC *2022$*
EL0	0.6597 – (0.0009 x Vr)	$403.91
EL1	0.6797 – (0.0009 x Vr)	$410.90
EL2	0.7497 – (0.0009 x Vr)	$512.22
EL3	0.8397 – (0.0009 x Vr)	$581.66
EL4	0.9297 – (0.0009 x Vr)	$770.60
EL5	0.9997 – (0.0009 x Vr)	$801.30

* UEF standards vary based on the test procedure draw pattern that is used to determine the UEF rating. For simplicity and because all residential-duty gas-fired storage water heaters on the market are in the high draw pattern, only the high draw pattern efficiency levels are shown.

Table IV.18 Manufacturer Production Costs for Gas-Fired Instantaneous Water Heaters and Hot Water Supply Boilers

Thermal Efficiency Level	Thermal Efficiency	MPC *2022$*	
		Gas-Fired Tankless Water Heaters	Gas-Fired Circulating Water Heaters and Hot Water Supply Boilers
		250,000 Btu/h	399,000 Btu/h
E_t EL0	80%	$566.87	$1,259.70
E_t EL1	82%	$575.83	$1,270.95
E_t EL2	84%	$584.62	$1,355.79
E_t EL3	92%	$686.29	$3,146.59
E_t EL4	94%	$709.22	$3,329.25
E_t EL5	96%	$741.13	$3,511.91

8. Manufacturing Markups and Manufacturer Selling Price

To account for manufacturers' non-production costs and profit margin, DOE applies a non-production cost multiplier (the manufacturer markup) to the full MPC. The resulting MSP is the price at which the manufacturer can recover all production and non-production costs and earn a profit. To calculate the manufacturer markups, DOE used data from 10-K reports[40] submitted to the U.S. Securities and Exchange Commission ("SEC") by the three publicly-owned companies that manufacture CWH equipment. DOE averaged the financial figures spanning the years 2008 to 2013 in order to calculate the initial estimate of markups for CWH equipment for this rulemaking. During interviews conducted ahead of the withdrawn May 2016 CWH ECS NOPR, DOE discussed the manufacturer markup with manufacturers and used the feedback to modify the manufacturer markup calculated through review of SEC 10-K reports. DOE considers the manufacturer markup published in the May 2016 CWH ECS NOPR to be the best publicly available information. In this final rule, DOE is maintaining the manufacturer markups used previously in the May 2016 CWH ECS NOPR, as DOE has not received any additional information or data to indicate that a change would be warranted.

To calculate the MSP for CWH equipment, DOE multiplied the calculated MPC at each efficiency level by the manufacturer markup. See chapter 12 of the final rule

[40] U.S. Securities and Exchange Commission, Annual 10-K Reports (Various Years) (Available at *sec.gov*).

TSD for more details about the manufacturer markup calculation and the MSP calculations.

9. Shipping Costs

Manufacturers of CWH equipment typically pay for shipping to the first step in the distribution chain. Freight is not a manufacturing cost, but it is a substantial cost incurred by the manufacturer that is passed through to consumers. Therefore, DOE accounted for shipping costs of CWH equipment separately from other non-production costs.

DOE research suggests that trailers either cube-out (*i.e.*, run out of floor space or storage volume) or weigh-out (*i.e.*, reach their allowed weight limits). Because storage water heaters are filled with air during shipping and instantaneous water heaters and hot water supply boilers are typically lighter than commercial storage water heaters, DOE research suggests that trailers filled with CWH equipment will typically cube-out before they weigh-out. Additionally, because the space above and around the CWH equipment can be filled with smaller and/or lighter products, DOE understands that trailers are typically filled in a way that maximizes the available storage space. As a result, changes to the cubic volume of the product are just as critical as changes to the footprint in determining the change to the shipping cost as unit size increases. DOE's shipping cost analysis only includes estimates of the shipping costs for CWH equipment, not for other products that may be included in the same truckload, although CWH equipment is likely to be shipped alongside other products, presumably to make efficient use of the space in shipping trailers.

Therefore, in this rulemaking, shipping costs for all classes of CWH equipment were determined based on the cubic volume occupied by the representative units. DOE first calculated the cost per usable unit volume of a trailer, using the standard dimensions of a volume of a 53-foot trailer and an estimated 5-year average cost per shipping load that approximates the cost of shipping the equipment from the middle of the country to either coast. Based on its experience with other rulemakings, DOE recognizes that trailers are rarely shipped completely full and, in calculating the cost per cubic foot, assumed that shipping loads would be optimized such that on average 80 percent of the volume of a shipping container would be filled with cargo. The calculated cost to ship each unit was the ratio of the unit's total volume (including packaging) divided by the volume of the shipping container expected to be filled with cargo and multiplied by the total cost of shipping the trailer. DOE recognizes that its shipping costs do not necessarily reflect how every unit of CWH equipment is shipped, that it is possible that units are shipped differently, and that the corresponding shipping costs may differ from DOE's estimates based on a variety of factors such as composition of the units in a given shipping load and the actual manufacturing location and shipment destination. However, DOE's analysis is intended to provide an estimate of the shipping cost that is representative of the cost to ship the majority of CWH equipment shipments and cannot feasibly account for the shipping costs of every individual unit shipped. Chapter 5 of the final rule TSD contains additional details about DOE's shipping cost assumptions and DOE's shipping cost estimates.

Rheem expressed support for DOE's method of calculating a representative shipping cost, and notes that a trailer volume of 80 percent is reasonably conservative.

(Rheem, No. 24 at p. 8) However, Bradford White suggested that DOE's use of a 5-year average in shipping costs is not accurate due to dramatic increases in shipping costs in the past 2 to 3 years. (Bradford White, No. 23 at p. 6).

In response, for this final rule DOE used the most current shipping costs available at the time of the analysis to determine the per unit shipping cost, rather than a 5-year average. DOE agrees with Bradford White that this more accurately reflects current costs.

D. Markups Analysis

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

DOE developed baseline and incremental markups for each actor in the distribution chain. DOE developed supply chain markups in the form of multipliers that represent increases above equipment purchase costs for key market participants, including CWH equipment wholesalers/distributors, retailers, and mechanical contractors and general contractors working on behalf of consumers. 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.[41]

1. Distribution Channels

Four different markets exist for CWH equipment: (1) new construction in the residential buildings sector, (2) new construction in the commercial buildings sector, (3) replacements in the residential buildings sector, and (4) replacements in the commercial buildings sector. DOE developed eight distribution channels to address these four markets.

For the residential and commercial buildings sectors, DOE characterizes the replacement distribution channels as follows:

- Manufacturer → Wholesaler → Mechanical Contractor → Consumer

- Manufacturer → Manufacturer Representative → Mechanical Contractor → Consumer

- Manufacturer → Retailer → Mechanical Contractor → Consumer

[41] 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.

DOE characterizes the new construction distribution channels for the residential and commercial buildings sectors as follows:

- Manufacturer → Wholesaler → Mechanical Contractor → General Contractor → Consumer

- Manufacturer → Manufacturer Representative → Mechanical Contractor → General Contractor → Consumer

- Manufacturer → Retailer → General Contractor → Consumer

In addition to these distribution channels, there are scenarios in which manufacturers sell CWH equipment directly to a consumer through a national account, or a consumer purchases the equipment directly from a retailer. These scenarios occur in both new construction and replacements markets and in both the residential and commercial sectors. In these instances, installation is typically accomplished by site personnel. These distribution channels are depicted as follows:

- Manufacturer → Consumer

- Manufacturer → Retailer → Consumer.

2. Comments on the May 2022 CWH ECS NOPR

Joint Gas Commenters note that while markups vary between new and replacement, there is very little difference between the values. (Joint Gas Commenters, No. 34 at p. 19) DOE relies on U.S. Census and other sources of data, some of which cannot be separated accurately into new and replacement segments, or when it can be separated the differences are small. When component pieces are combined to form markups, the new and replacement markup factors incorporate either the same inputs or inputs with small variations.

3. Markups Used in this final rule

Consistent with the May 2022 CWH ECS NOPR, to develop markups for this final rule, DOE utilized several sources, including the following: (1) The Heating, Air-Conditioning & Refrigeration Distributors International ("HARDI") 2013 Profit Report[42] to develop wholesaler markups; (2) the 2020 ACCA Cool Insights document containing financial analysis for the heating, ventilation, air-conditioning, and refrigeration ("HVACR") contracting industry[43] to develop mechanical contractor markups; (3) the U.S. Census Bureau's 2017 Economic Census data[44] for the commercial and institutional building construction industry to develop mechanical and general contractor markups;

[42] Heating Air-conditioning & Refrigeration Distributors International. Heating, Air-Conditioning & Refrigeration Distributors International 2013 Profit Report.
[43] Air Conditioning Contractors of America (ACCA). Cool Insights 2020: ACCA's Contractor Financial & Operating Performance Report (Based on 2018 Operations). 2020.
[44] U.S. Census Bureau. 2017 Economic Census Data. 2020. Available at *www.census.gov/programs-surveys/economic-census.html*. The 2017 Economic Census is the most recent census available. The next census, the 2022 Economic Census, is scheduled to begin releasing results in 2024.

and (4) the U.S. Census Bureau's 2017 Annual Retail Trade Survey[45] data to develop retail markups.

In addition to markups of distribution channel costs, DOE derived State and local taxes from data provided by the Sales Tax Clearinghouse.[46] Because both distribution channel costs and sales tax vary by State, DOE developed its markups to vary by State. Chapter 6 of the final rule TSD provides additional detail on markups.

E. Energy Use Analysis

The purpose of the energy use analysis is to assess the energy requirements (*i.e*., annual energy consumption) of CWH equipment described in the engineering analysis for a representative sample of building types that utilize the equipment, and to assess the energy-savings potential of increased equipment efficiencies. The energy use analysis estimates the range of energy use of CWH equipment in the field (*i.e.*, as the equipment is 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.

The energy use for commercial water heaters varies by type of commercial or residential building, by region, and by type and size of CWH equipment. As explained in more detail below, and in the NOPR, for this rulemaking, the energy use for water heaters

[45] U.S. Census Bureau. 2017 Annual Retail Trade Survey. 2019. Available at *www.census.gov/retail/*.
[46] *The Sales Tax Clearing House*. 2022. Available at *www.thestc.com/STrates.stm*. Last accessed December 4, 2022.

is estimated by identifying the various commercial buildings or residential buildings in EIA's 2020 CBECS or 2009 RECS that utilize natural gas for water heating and, for these buildings, estimating the hot water used in gallons per day, taking into account the building type and the presence of specific building activities. At the same time, DOE identified from the same sample those buildings with estimated peak hot water loads large enough to need commercial water heaters of the type examined in this rulemaking. DOE's assessment of peak hot water loads considered characteristics of the individual building including occupancy, building type, floorspace, and other specific sampled data that are used in sizing water heating systems, e.g. number of rooms in hotel or dormitory, beds in a health care facility, seats in a restaurant, etc. When considering multifamily residential, only buildings that indicate the use of central hot water systems serving multiple apartments are considered candidates for commercial water heaters. For those buildings with large enough peak hot water demand, DOE used the estimated annual hot water usage (gallons/day) for each of the buildings within the sample, the incoming water temperatures, by month, derived for the location, and the expected hot water delivery temperature to calculate the annual hot water load (Btu/yr) for the building, including additional piping circulation energy losses where appropriate. DOE converts this to an average hot water load in (Btu/day).

For each type of commercial water heater, DOE calculates the output capacity of the representative size water heater at design conditions and at the baseline efficiency level, taking into account the usable storage volume, where applicable, and the length of the peak sizing period in hours based upon industry sizing guidance. Then for each of the above buildings, DOE divides the daily hot water load requirements by the hourly capacity of the water heater over the sizing period to get the daily average burner operating hours necessary to meet the above hot water load for the baseline unit at full output. Then for the remaining hours in the day, DOE uses the water heater hourly standby energy loss rate to calculate daily average standby loss energy consumption. The daily energy consumption at baseline efficiency is calculated as the operating hours to meet the building hot water load times the full load input of the water heater plus the daily energy consumed to meet the water heater standby loss. The average daily energy for the equipment is then multiplied by the number of days in a year to get annual energy consumption.

For the rulemaking, DOE is assessing the effect efficiency improvements have on energy consumption. For the representative equipment in each class, the burner operating hours to meet the building load requirements decreases with improved efficiency. DOE uses the decreased operating hours to calculate the annual energy consumption for the water heater at each higher efficiency level considered. Chapter 7, appendix 7A, and appendix 7B present further detail regarding the water sizing methodology and estimation of building hot water loads and corresponding energy consumption by efficiency level.

DOE estimated the annual energy consumption of CWH equipment at specified energy efficiency levels across a range of commercial and multifamily residential buildings in different climate zones, with different building characteristics, and including different water heating applications. The annual energy consumption includes use of natural gas (or liquefied petroleum gas ("LPG")) as well as use of electricity for auxiliary components.

DOE developed representative hot water volumetric loads and water heating energy usage for the selected representative products for each equipment category and building type combination and efficiency level analyzed. This approach used by DOE captures the variability in CWH equipment use due to factors such as building activity, schedule, occupancy, tank losses, and distribution system piping losses.

CWH equipment analyzed in this rulemaking is used in commercial building applications and certain residential applications, particularly multifamily buildings. For commercial sector buildings, DOE used the daily load schedules and normalized peaks from the 2013 DOE Commercial Prototype Building Models[47] to develop gallons-per-day hot water loads for the analyzed commercial building types.[48] For this final rule, DOE assigned the corresponding hot water loads on a square-foot basis to associated commercial building records in the EIA's 2018 CBECS[49] in accordance with their detailed principal building activity subcategories. For residential building types, DOE used the hot water loads model developed by Lawrence Berkeley National Laboratory ("LBNL") for the 2010 rulemaking for "Energy Conservation Standards for Residential Water Heaters, Direct Heating Equipment, and Pool Heaters."[50] For this final rule, DOE applied this model to the residential building records in the EIA's 2009 Residential

[47] U.S. Department of Energy–Office of Energy Efficiency and Renewable Energy. Commercial Prototype Building Models. 2013. Available at *www.energycodes.gov/prototype-building-models*.
[48] Such commercial building types included the following: small office, medium office, large office, stand-alone retail, strip mall, primary school, secondary school, outpatient healthcare, hospital, small hotel, large hotel, warehouse, quick service restaurant, and full-service restaurant.
[49] U.S. Energy Information Administration (EIA). 2018 Commercial Building Energy Consumption Survey (CBECS) Data. 2018. Available at *www.eia.gov/consumption/commercial/data/2018/*.
[50] U.S. Department of Energy–Office of Energy Efficiency and Renewable Energy. Final Rule Technical Support Document: Energy Conservation Standards for Residential Water Heaters, Direct Heating Equipment, and Pool Heaters. April 8, 2010. EERE-2006-STD-0129-0149. Available at *www.regulations.gov/#!documentDetail;D=EERE-2006-STD-0129-0149*.

Energy Consumption Survey ("RECS").[51] For the May 2022 CWH ECS NOPR DOE decided not to use the 2015 RECS because it lacked information including the number of apartments and the number of floors in the building of apartment observations, and other information such as householder age distributions was less robust than in the 2009 RECS dataset. Because of the data issues with the 2015 RECS and because the 2020 RECS was not yet final at the time the final rule analysis was completed, DOE maintained use of the 2009 RECS. For RECS housing records in multi-family buildings, DOE focused only on apartment units that share water heaters with other units in the building. Since the LBNL model was developed in part to analyze individual apartment hot water loads, DOE had to modify it for the analysis of shared water heater/ whole building loads. DOE established statistical average occupancy of RECS apartment unit records when determining the individual apartment unit's load. DOE also developed individual apartment loads as if each were equipped with a storage water heater in accordance with LBNL's methodology. Then, DOE multiplied the apartment unit's load by the number of representative units in the building to determine the building's total hot water load.

DOE converted daily volumetric hot water loads into daily Btu energy loads by using an equation that multiplies a building's gallons-per-day consumption of hot water by the density of water,[52] specific heat of water,[53] and the hot water temperature rise. To calculate temperature rise, DOE developed monthly dry bulb temperature estimates for each U.S. State using typical mean year ("TMY") temperature data as captured in

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[51] U.S. Energy Information Administration (EIA). 2009 Residential Energy Consumption Survey (RECS) Data. 2009. Available at *www.eia.gov/consumption/residential/data/2009/*.

[52] DOE used 8.29 gallons per pound.

[53] DOE used 1.000743 Btu per pound per degree Fahrenheit.

location files provided for use with the DOE EnergyPlus Energy Simulation Software.[54] Then, these dry bulb temperatures were used to develop inlet water temperatures using an equation and methodology developed by the National Renewable Energy Laboratory ("NREL").[55] DOE took the difference between the building's water heater set point temperature used in its energy analysis and the inlet temperature to determine temperature rise (see chapter 7 of the final rule TSD for more details). In addition, DOE developed building-specific Btu load adders to account for the heat losses of building types that typically use recirculation loops to distribute hot water to end uses. DOE converted daily average hot water building loads (calculated for each month using monthly inlet water temperatures) to annual water heater loads for use in determining annual energy use for the representative water heaters at each efficiency level analyzed.

DOE developed a maximum hot water loads methodology for buildings for determining the number of representative equipment needed using the data and calculations from a major water heater manufacturer's sizing calculator.[56] DOE notes that the sizing calculator used was generally more comprehensive and transparent in its maximum hot water load calculations than other publicly available sizing calculators identified. For the final rule this methodology was applied to selected commercial building records in 2018 CBECS and residential building records in 2009 RECS to determine peak gallons-per-hour requirements, assuming a temperature rise specific to

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[54] U.S. Department of Energy–Office of Energy Efficiency and Renewable Energy. EnergyPlus Energy Simulation Software. TMY3 data.

[55] Hendron, R. *Building America Research Benchmark Definition, Updated December 15, 2006*. January 2007. National Renewable Energy Laboratory: Golden, CO. Report No. TP-550-40968. Available at *www.nrel.gov/docs/fy07osti/40968.pdf*.

[56] A.O. Smith. *Pro-Size Water Heater Sizing Program*. Available at *www.hotwatersizing.com/*. Last accessed in December 20, 2022.

the building, for sizing of the water heater system. For buildings with sizing based greater than one hour sizing periods, the average gallons per hour requirement during the peak was developed. DOE divided these peak hourly hot water loads by the average hourly hot water delivery capability of the baseline representative model of each equipment category over the sizing period, including in the case of circulating water heaters and boilers the usable hot water storage of external storage tanks over that period, to determine the number of representative water heater units required to service the maximum load. For each representative unit of the CWH equipment analyzed for the final rule, DOE examined the individual CBECS and RECS building peak hot water loads to find those building observations whose loads indicated a need of at least 0.9 water heaters, based on the representative model analyzed, to fulfill their maximum load requirements. Due to the maximum input capacity and storage specifications of residential-duty commercial gas-fired storage water heaters, DOE limited the buildings sample of this equipment class to building records requiring four or fewer representative water heaters to fulfill maximum load since larger maximum load requirements are more likely served by larger capacity equipment. For gas-fired tankless water heaters, a similar limit of four units per building was set. For the commercial gas-fired storage and the instantaneous water heaters and hot water supply boiler equipment classes, DOE set an upper limit at 40 units. DOE recognizes that these two equipment classes cover a wide range of capacities, and 40 units is equivalent to a much smaller of very large units in the same equipment classes. This limit had the effect of eliminating a small number of exceptionally large loads from consideration. In addition, for gas-fired tankless water heaters, an adjustment factor was applied to the first-hour capability to account for the shorter time duration for sizing this equipment, given its minimal stored water volume. DOE used the Modified Hunter's Curve method,[57] which estimates a maximum water demand of a building accounting for statistical probabilities for simultaneous fixture use for sizing of instantaneous water heaters to develop the adjustment factors for commercial gas-fired tankless water heaters. The applied adjustment factor modifies the first hour delivery capability calculations of commercial gas-fired tankless water heaters to account for the shorter time duration used to size for a very short "instantaneous" peak for this equipment, given the minimal volume of stored water to buffer meeting short duration peaks during the 1-hour maximum load period used for the first hour rating. Gas-fired circulating water heaters and hot water supply boilers as a class were teamed with unfired storage tanks to determine their first-hour capabilities since this is the predominant installation approach for this equipment. (See appendix 7B of the final rule TSD).

For each equipment type being examined, DOE sampled all RECS and CBECS buildings that were deemed suitable for the development of the representative loads for that equipment type using a Monte Carlo analysis in the LCC model; the Monte Carlo analysis randomly generates values for uncertain variables from expected distributions of these variables to simulate input variability in a model (see appendix 8B of the final rule TSD for a more detailed description). For each building sampled, DOE divided the buildings daily average hot water demand, in Btu, including pipe circulating losses, by the product of the output hot water heating capability of the representative water heater

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[57] PVI Industries Inc. "Water Heater Sizing Guide for Engineers," Section X, pp. 18–19. Available at *oldsizing.pvi.com/pv592%20sizing%20guide%2011-2011.pdf.*

unit examined and the total number of representative units required for the sampled building to provide estimate the average daily hours of full load operation to serve the building hot water needs for that representative unit. The remainder of the hours in the day represent hours of standby mode. For DOE's analysis, the number of water heaters allocated to a specific building was held constant at the baseline efficiency level, but as the heating output of each representative unit increases with thermal efficiency, a water heater's hours of operation decreased as its thermal efficiency improved. This decrease in operating hours, in combination with changes in standby hours and standby loss performance at each efficiency level, results in changes in energy consumption at each efficiency level above the baseline. In the case of residential-duty gas-fired storage water heaters, DOE estimated the thermal efficiency and standby loss levels for each UEF level developed in the Engineering Analysis using the same methodology as for the NOPR. This conversion is discussed in Chapter 7 of the final rule TSD. Section IV.C.4 of this final rule and chapter 5 of the final rule TSD include additional details on the thermal efficiency, standby loss, and UEF levels identified in the engineering analysis.

DOE received multiple comments on the use of CBECS and RECS data in its energy use analysis presented in the May 2022 CWH ECS NOPR. For the NOPR, DOE's analysis used the 2012 CBECS and 2009 RECS in developing building samples. Multiple stakeholders stated that DOE should use newer data, pointing specifically to the availability of CBECS 2018 and RECS 2020 data. (AHRI, No. 31 at p. 2; Joint Gas Commenters, No. 34 at p. 33; Rheem, No. 24 at p. 2) Patterson-Kelley stated that they reviewed the most current versions of RECS and CBECS with the understanding that these would be used in the final rule. (Patterson-Kelley, No. 26 at p. 4) CA IOUs indicated support for DOE's proposed minimum efficiency standards if DOE updated the analyses with newer data including specifically the more recent CBECS. (CA IOUs, No. 33 at p. 1) Similarly, the Joint Gas Commenters urged DOE to use the most current available data and stated DOE should halt the rulemaking until this data was appropriately evaluated. (Joint Gas Commenters, No. 34 at p. 33)

In response to comments that DOE should use the latest CBECS and RECS, for the final rule, DOE used the 2018 CBECS, but maintained use of the 2009 RECS data. The CBECS 2018 data is the most current CBECS dataset for which the commercial building characteristics data used by DOE is available. DOE considered using the RECS 2015 and 2020 datasets. Both datasets lack the number of floors and the number of apartments in apartment buildings, as well as some disaggregated data concerning the ages of building occupants, all of which are needed for the analysis and which were included in the 2009 RECS. Additionally, the 2020 RECS was not finalized when the final rule analysis was being completed, meaning that data could change after the final rule analysis was completed which could complicate third-party review of DOE's models and data after the final rule is published. Because both the 2015 RECS and 2020 RECS lack key data fields, and additionally because the 2020 RECS dataset was not yet finalized, DOE used 2009 RECS data for this final rule. It should be noted that the update to CBECS 2018 did not represent a change in the methodology or tools used to generate results. Rather, using the more recent CBECS data set is functionally little different than updating other data sets such as using 2022 RSMeans labor rates rather than 2021 RSMeans labor rates. DOE replaced the CBECS data in the LCC model with little difficulty given that all relevant data fields existed in the new CBECS data.

Patterson-Kelley questioned the use of RECS and CBECS given concerns about the appropriateness of the data. (Patterson-Kelley, No. 26 at p. 4) WM Technologies expressed certain concerns with the appropriateness of DOE's use of RECS and CBECS data sets in its analysis and provided several comments, particularly examining the 2015 RECS and 2018 CBECS data, which was the most recent available at that time. In particular they commented that (1) the RECS process normalized data toward the median values through a process referred to as minimum variance estimation and therefore the variation in the data was minimized, (2) RECS data do not agree with other surveys on energy use due to how questions were asked and data edited, and (3) that more than one half of the 2015 RECS square footage data were estimated using an imputation method, and the overall imputation rate of these data was 65.6 percent. WM Technologies further states that the documented variation in the published RECS data was not included in the LCC analysis, which is expected to become significant when the department reviews subgroups and must be corrected to assure an accurate analysis. With respect to CBECS, WM Technologies stated that the primary sampling unit for major cities focused on areas with significant commercial activity while other primary sampling units were selected at random and that this biased building selection toward high revenue generating areas. The noted sampling rates for large buildings were higher than small buildings and thus overstates energy consumption for the LCC, that subgroups within CBECS with highly variable energy consumption were sampled at a higher rate than subgroups with less variable energy consumption, and finally the energy consumption from CBECS is an estimate at best and includes a category of end use as other, resulting in significant uncertainty in results. (WM Technologies, No. 25 at pp. 3–4)

DOE considered the comments from WM Technologies on the use of RECS and CBECS data sets; however, DOE disagrees with the WM Technologies conclusions with regard to DOE's analysis.

Regarding the discussion of the RECS use of minimum variance estimation, this is discussed in EIA's 2015 Consumption and Expenditures Technical Documentation Summary[58] when calibrating the end use estimates from modeling end uses for each household to the measured annual energy use totals that are collected by EIA in the development of RECS. It is not clear from the WM Technologies comment exactly what is the concern with EIA's use of this in calibration; however, DOE's use of RECS for this rulemaking is as a source for household characteristics data used for the generation of hot water loads. DOE is not using the 2015 RECS and does not use energy end use estimates from the 2015 RECS. Thus, DOE does not believe this discussion of minimum variance estimation is relevant to this rulemaking.

WM Technologies also notes that 2015 RECS data do not agree with other surveys on energy use due to how questions were asked and data edited, and cites EIA's webpage for the discussion of this, although generally not providing detail on why this variation was considered problematic except expressing the concern with the high ratio of imputed data for household square footage. In response to these points, DOE notes that the 2015 RECS was not used in this final rule and to this extent the comments are not

[58] U.S. Energy Information Administration (EIA). 2015 Consumption and Expenditures Technical Documentation Summary. May 2018. Available at *www.eia.gov/consumption/residential/reports/2015/methodology/pdf/2015C&EMethodology.pdf.*

applicable to the final rule analysis. In reviewing the cited discussion from EIA, DOE notes that much of the discussion is focusing on end use estimation. In fact, in the discussion from EIA comparing against previous RECS analysis, EIA specifically notes that it believes the updated modeling and calibration method are an improvement over previous RECs estimation methods. However, other differences noted by EIA were that it was a smaller sample than the 2009 RECS and that it relied extensively on self-administered web and paper questionnaires to supplement the traditional, computer-assisted personal interview and indicated that where household data relied exclusively on web and paper inputs, all square footage estimates for homes were imputed. There is discussion provided by EIA comparing or contrasting RECS with other Federal studies that may provide insight into residential energy demand. In this discussion, EIA provides a very clear note that these studies are optimized to serve a different purpose from the RECS and so their results for similar items may vary from the RECS. The RECS study is designed specifically for the analysis of current U.S. household energy consumption, unlike the other studies it is contrasted with. With regard to the WM Technologies concern that CBECS and the building sampling are biased toward large buildings in commercial areas, resulting in overstating consumption in the LCC - there are several reasons why this is incorrect. First, CBECS samples are assigned weights where the assignment process uses data from other larger building data "frames" and sources so that the weight represents the building itself and other similar buildings within the U.S. population. As the samples are in fact weighted and DOE uses these weights when sampling within the LCC, the oversampling of large buildings does not translate to a bias in the final CBECS weighted sample. Second, DOE's use of CBECS for this rulemaking is for the development of building characteristics data and not based on the end use energy estimates. In its review, DOE does not feel that the concerns expressed by WM technologies regarding RECS or CBECS are important or relevant to the use of these data sets in the final rule analysis.

DOE notes that the analysis accounts for recirculation loop losses in average daily hot water loads. In its final rule analysis, DOE assigned insulated supply, return, and riser recirculation loop piping to sampled buildings with a year of construction of 1970 or later. For buildings constructed prior to 1970, DOE assigned uninsulated supply piping to 25 percent of sampled buildings and uninsulated return piping to 25 percent of sampled buildings. DOE acknowledges that its energy use analysis may not account for the extent of all possible heat losses such as from poor control of circulating system flow, uninsulated or poorly insulated piping, leaks or other higher than expected tap flows, and poor water heater performance due to aging. These issues may result in higher hot water energy use than predicted by DOE's models. Due to the lack of field data on the magnitude of these energy losses across building applications, vintage, and location, DOE did not further attempt to include them into its analysis. DOE develops daily hot water loads for each building analyzed and normalizes building hot water loads to the hot water service capacity of the representative products using industry sizing tools and methodologies. DOE acknowledges that its approach for a given building loads treats multiple units for CWH equipment as equally sharing the hot water load.

To the extent that commenters may be concerned whether the analysis fairly represents individual water heater operation for water heaters in buildings in which multiple representative model units operate to meet the building's load, DOE notes that this would be system and building specific and its analysis may not capture the extremes of hot water loading on an individual water heater in all applications but would capture the average hot water loads on the equipment in those building. DOE notes that its analysis examines maximum sizing hot water loads and average daily hot water loads of 17 commercial building applications and 4 residential building applications, with additional variability in terms of specific end uses where identified in the CBECS or RECS data including variability based on inputs such as occupants, water fixtures, clothes washers, dishwashers, and food service as well as water main inlet and outlet temperatures for estimating hot water loads. It also includes estimates of piping losses in circulating systems. Chapter 7 and appendix 7B in the final rule TSD describe the calculation of hot water loads in the building. Appendix 7B also provides a table of building types that DOE assumed to use recirculation loops, as well as the operation hours of the recirculation loops.

All of this variability is accounted for in the weighted results of the Monte Carlo analysis. While there may be further variability in hot water loads between multiple, individual water heaters operating in unison to meet a building's hot water load, DOE's analysis focuses on equipment operation over longer timeframes and developing representative loads for the equipment in the building. Equipment operated in unison in a building will experience, on average and over large populations represented, energy use reflecting the per-unit averaged building hot water load. As such, DOE did not directly account for the variability in operation of individual equipment when multiple units are installed and operated in tandem. DOE notes that with condensing equipment in particular, operation in parallel under part-load conditions can result in higher thermal efficiencies than those obtained under rated conditions, which reflect peak load thermal efficiencies. However, due to lack of detail of actual multiple water heaters installations exist the sampled buildings, DOE did not take this potential increase in field-efficiency into account.

DOE notes that its sizing methodology was based on industry sizing tools and guidelines and was used to establish peak water heat loads that would reflect the anticipated peak in the buildings based on those guidelines and known or estimated building characteristics. These peaks were then used to establish the number of representative units (by CWH type) that would be installed to meet the anticipated peak loads, with the hot water load apportioned across the estimated number of representative units needed. DOE notes that its sizing methodology was customized to the building application, size, and accounted for building size, occupancy, and specific end uses. For the hot water delivery capability of each equipment category, DOE uses representative equipment designs. The representative design of each equipment category has a specific input capacity and volume as shown in Table IV.5 of this document. These representative specifications are used in a calculation of hot water delivery capability. For each equipment category, DOE sampled CBECS and RECS building loads in need of at least 0.9 water heaters of the representative capacity, based on the representative model analyzed, to fulfill their maximum load requirements, and allows multiple representative units to serve the building load. As a result, DOE does not adjust input capacity and volume of equipment for a given building application.

In addition, DOE assumed the circulating water heater equipment class is equipped with a storage tank since this is the predominant installation configuration for this equipment. For this equipment class and representative input capacity, the analysis used a variable storage tank size of 250 to 350 gallons in volume, based on a triangle distribution consistent with manufacturer literature guidance as to typical storage tanks for the representative equipment input rating. However, DOE recognizes that for this equipment class as well, further variation in the storage tank sized with the equipment might also occur based on each individual building owner's preferences. DOE retained this use of representative installation practices for the final rule analysis. Chapter 7 of the final rule TSD provides more information on the hot water delivery calculations for circulating water heaters.

DOE's energy use analysis used the A.O. Smith Pro Size Water Heating Sizing Program as a primary resource in determining the type, size, and number of water heaters needed to meet the hot water demand load applications. DOE did not identify a universal industry sizing methodology and reviewed a number of online sizing tools prior to its decision to use A.O. Smith's online sizing tool as the basis for its water heater sizing methodology. Based on DOE's initial review, the chosen sizing tool was most appropriate because of its transparency allowing it to be evaluated for fixture flow assumptions and other industry-accepted sizing methodologies. This tool provided peak-hour delivery in its sizing output, whereas several others manufacturing sizing tools reviewed provided equipment recommendations and/or equipment sizes only in their outputs. DOE reviewed the relationships between input data and outputs for this tool in detail for use in establishing the basis for its sizing calculations and made certain adjustments to improve the accuracy of its maximum load determinations, as shown in detail in appendix 7B.

DOE utilized the Modified Hunter's Curve approach for developing hot water delivery adjustment factors, or divisors, to adapt the sizing methodology for water heaters with storage to a methodology suitable for sizing water heaters without storage. DOE used the PVI Industries "Water Heater Sizing Guide for Engineers" which implements the Modified Hunter's Curve approach to develop the adjustment factors for sizing tankless water heaters. DOE's research indicates that mechanical contractors and design engineers commonly rely on this general sizing methodology for determining appropriately-sized equipment to install in commercial and residential buildings, and the PVI tool captures the need and general industry methodology required to size tankless water heating equipment to address short-duration loads peaks. In addition, DOE consulted the *ASHRAE Handbook of HVAC Applications*,[59] which provides guidance for sizing tankless and instantaneous water heaters. While the ASHRAE guidance also illustrates the Modified Hunter's Curve methodology, it was not as clear in application as the guidance provided by PVI tool. In this area of CWH equipment selection, DOE research indicates that manufacturer sizing tools are more commonly used than ASHRAE handbooks. Because of the lack of storage and the need to meet instantaneous building loads at sub-hour intervals, the sizing strategy for instantaneous water heaters results in a lower hot water service and lower energy consumption per unit of input capacity than is

[59] American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc. (ASHRAE). *ASHRAE Handbook of HVAC Applications: Chapter 51 (Service Water Heating)*. 2019. pp. 51.1–51.37. Available at *www.ashrae.org/resources--publications/handbook*.

the case for either storage water heaters, or equipment like circulating water heaters and hot water boilers where separate storage tanks are typically used.

To clarify how DOE developed the inlet water temperature, DOE conducted its energy use analysis using a Monte Carlo approach, selecting commercial building records from CBECS and residential building records from RECS in the development of maximum and daily hot water loads. Daily hot water loads were converted to energy use based on the equipment operation necessary to meet the load. Each building record's location is associated with geographic regions composed of one or multiple U.S. States in the case of RECS (referred to herein as "reportable domains"), and a Census Division in the case of CBECS. Using this location, DOE assigned an average monthly inlet temperature for the location the building resided in using monthly dry bulb temperature estimates for each location based on the TMY temperature data as captured in location files provided for use with the DOE EnergyPlus energy simulation software,[60] along with an equation and methodology developed by NREL.[61] Where CBECS data are used, DOE used weighted average data across the states within the division, with data being weighted by state population. Where RECS data are used, DOE used weighted average data across the states within the reportable domain, with data being weighted by state population. DOE then summed the daily hot water loads of each month to determine the monthly hot water loads. DOE then summed the monthly hot water loads to determine

[60] U.S. Department of Energy–Office of Energy Efficiency and Renewable Energy. EnergyPlus Energy Simulation Software. TMY3 data. Available at *apps1.eere.energy.gov/buildings/energyplus/cfm/weather_data3.cfm/region=4_north_and_central_america_wmo_region_4/country=1_usa/cname=USA*. Last accessed October 2014.

[61] Hendron, R. *Building America Research Benchmark Definition, Updated December 15, 2006*. January 2007. National Renewable Energy Laboratory: Golden, CO. Report No. TP-550-40968. Available at *www.nrel.gov/docs/fy07osti/40968.pdf*.

annual hot water loads. For a given hot water usage, as inlet temperature is colder, energy use increases, since the water heater must impart more heat to bring the inlet temperature to the set point temperature. Chapter 7 of the final rule TSD provides detailed information on how energy use was calculated using inlet water temperature.

As stated, DOE developed daily hot water loads for building applications using the building service water heating schedules in the 2013 DOE commercial prototype building models. While there may be greater variation of individual usage schedules in the general population even within a building type, DOE's use of these typical schedules and weighting by the relative frequency of the buildings in the general population is appropriate for the energy use analysis.

DOE notes that there is limited actual data on commercial hot water usage in the field. To the extent that stakeholders feel that DOE's analysis may under or overstate hot water usage, DOE notes that the analysis reflects both variation in direct hot water loads, inlet and outlet temperatures and piping/recirculation losses with a referenced estimating procedure. While DOE recognizes that additional energy losses can occur in the field, to the extent that these losses occur, it suggests that the results of DOE's energy use analysis are conservative. In this final rule, DOE used schedules and loads from ASHRAE prototype models with augmented data reflecting recent standards affecting water heater used by commercial appliances and equipment. The commercial building hot water loads based on the daily schedules and square footage from the scorecards of the 2013 DOE commercial prototype building models and corresponding normalized peak water heater loads from the DOE EnergyPlus energy simulation input decks for these prototypes were vetted by the ASHRAE 90.1 Committee. DOE developed residential building hot water loads using the hot water loads model created by the LBNL for the 2010 final rule for Energy Conservation Standards for Residential Water Heaters, Direct Heating Equipment, and Pool Heaters. 75 FR 20112 (April 16, 2010). These data sources reflect expected hot water use at the time of their publication, including reductions of typical hot water use for certain appliances and commercial equipment based upon amended Federal standards and certain voluntary programs where those appliances are identified as part of the end use. DOE notes that its analysis and any eventual CWH standards are dominated by existing buildings and influenced by a lesser extent by shipments to new construction. Furthermore, DOE notes that to the extent that regulatory standards have or will reduce water loads, manufacturer sizing tools (as used in DOE's analysis for sizing water heaters in different applications) should also reflect the reduction in water usage for sizing purposes, thereby minimizing the impact of reduced hot water loads resulting from DOE regulation on the overall economic evaluation of higher standards.

With regards to the use of CWH equipment in residential buildings, DOE clarifies here that the only residential building type specifically excluded from the analysis of CWH equipment was manufactured housing,[62] since DOE determined that manufactured housing is not suitable for any CWH equipment installation or use. A manufactured home would have hot water loads which require a commercial water heater. Otherwise,

[62] A manufactured home is defined as "a structure, transportable in one or more sections, which in the traveling mode is 8 body feet or more in width or 40 body feet or more in length or which when erected on-site is 320 or more square feet, and which is built on a permanent chassis and designed to be used as a dwelling with or without a permanent foundation when connected to the required utilities, and includes the plumbing, heating, air-conditioning, and electrical systems contained in the structure. …" 24 CFR Subtitle B Chapter XX Part 3280. Available at *www.ecfr.gov/current/title-24/subtitle-B/chapter-XX/part-3280* (last accessed April 21, 2023).

for all other residential and commercial building types, if the estimated maximum sizing load of a sampled building was not at least 90 percent of the hot water delivery capability of the baseline representative model for any analyzed equipment category, then the building was not sampled since the building's maximum load is deemed not large enough to warrant the installation of the specific CWH equipment to service the load. Chapter 7 of the final rule TSD provides details of DOE's energy use analysis and sizing.

In response to the May 2022 CWH ECS NOPR, Bradford White noted that certain CWH equipment is designed to work within a limited delta T range (*i.e.*, temperature difference between the inlet and outlet of the water heater) in order to hit the rated efficiency and meet the needs of the application. Therefore, a 160 °F setpoint temperature will, in fact, decrease efficiency, as a limited delta T (*e.g.*, 20 °F) will keep the inlet to the water heater high enough that condensing will not occur. (Bradford White, No. 23 at p. 9) PHCC commented that to achieve condensing in practice, water temperatures must be below 140 °F and while this is easier to obtain in furnaces, with water products the storage temperature may be close to or exceed that temperature. Manufacturers of boilers will typically show an efficiency curve with return water temperature and show a transition between when a unit is condensing or not condensing. They further state that either way, if a consumer elects to have water temperatures of 140 °F or higher, the performance of the heater will not hit the 95 percent efficiency level. Perhaps the test method sets parameters that make 95 percent achievable but in the real world, that will not be the case. Furthermore, they note that a 140 °F consideration is very likely for kitchens and laundries. In addition, due to biofilm and legionella concerns, many facilities are moving toward higher storage temperatures to combat contaminants. (PHCC, No. 28 at p. 3)

In response to the comment by Bradford White, DOE is aware that certain instantaneous water heaters are designed as commercial booster water heaters and that some of these units may in fact be operated with high inlet water temperatures that would not allow condensing. While many booster water heaters are electric resistance units, DOE is aware that certain gas water heater products are on the market and examined several of these products. The units examined however appear to be capable of a wide range of temperature rise operation and not designed solely for low temperature rise applications. This appears to be more application specific choice on the part of the commercial user than a limitation of the water heater itself. Several of these units examined were rated as condensing water heaters. DOE understands that it is possible that in certain applications a unit like this may not condense, but it does not appear that this is a limitation of the water heater. Further, DOE believes that such products represent a niche market in the general class of gas instantaneous water heaters.

DOE is unaware of equipment rated as instantaneous water heaters that are capable of operation only under low temperature rise (*e.g.*, 20 ºF temperature rise) application. In general, hot water supply boilers, circulators, and volume water heaters designed to work with separate storage tanks also appear to be both tested according to the DOE test procedure and the available literature reviewed by DOE indicated were capable of operating at higher (*e.g.*, 70 ºF) temperature differentials between inlet and outlet. As discussed previously, that such equipment could be placed in an application in which it would not condense is possible, however it also appears that in many cases piping arrangements in such an application could be designed such that when cold inlet water enters the system (occurring whenever hot water is removed from the system), mixing valves or mixing stations can ensure that water going to the water heater is low enough to provide for condensing to occur. Many volume water heaters already provide for condensing efficiencies.

DOE further notes that water heaters are generally different than hydronic, space heating boilers in that where hot water is removed from the circulating system, cold water at the water main temperature is introduced into the system. While PHCC has suggested that at 140 °F storage temperature or higher, the performance of the heater will not hit 95 percent efficiency, DOE notes that the DOE test procedure for commercial water heaters presumes a 140 °F leaving water temperature already (and therefore, a similar storage temperature) and models are tested at that temperature and at full rated input capacity and many achieve thermal efficiencies higher than 95 percent. While there may be some degradation in performance at higher leaving water temperatures, DOE believes that with modern water heater designs, entering water temperature is the primary limitation on whether condensation occurs, not leaving water temperature. Further DOE notes that many commercial water heaters are designed with modulating burners, which further lower the burner heat output and increase the equipment efficiency beyond what may be envisioned at full rated output as per the DOE test procedure.

DOE is aware of a variety of opinions on the handling of legionella, but again notes that cool water will need to be heated in any water heating system and notes that the heating of such water is the majority of the hot water load on the water heaters in DOE's analysis.

PHCC expressed concern that the estimated annual unit energy for commercial water heaters is understated. To perform a simple check on the estimates, PHCC divided unit energy by the input rating and the number of days per year, a calculation that yields the daily average hours of operation. PHCC notes that when these products are installed, restaurants, hotels, dormitories, hospitals, and such, it is hard to believe that these water heaters only operate for a few hours a day. PHCC believes that the basis for the energy use is understated for all categories of CWH products. (PHCC, No. 28 at p. 3)

In response, DOE notes that the primary inputs affecting the operating hours per day are the hot water load, including any circulation energy losses and the sizing of the water heater to meet the peak building needs. Standby losses from the water heater itself are also important but generally would result in only approximately 15–20 minutes of operation on a given day for a commercial gas storage or residential-duty water heater respectively even if the unit was in standby for the entire day. In addition, while restaurants, hotels, hospitals and dormitories would be expected to be high utilization end uses, commercial water heaters can also serve office and retail applications which might have comparatively small hot water loads per unit of water heater capacity. DOE's analysis has tried to incorporate both industry sizing tools (which potentially could be conservative) and estimates of hot water load across a wide variety of building applications, and represents relative frequency of use in these application through the use of CBECS and RECS sampling of buildings that could use the various classes of CWH equipment as described previously and in detail in the final rule TSD. DOE recognizes that in the end, however, operating hours, which provide a normalized representation of the energy consumption for a given size of purchased equipment, are a principle driver in the economics of DOE's life-cycle cost and other downstream analysis and to the extent that any class of commercial water heater operates on average more hours in a day than estimated by DOE, it would generally result in larger energy use and all else the same, correspondingly larger energy savings than estimated by DOE.

PHCC noted that at the 2022 Emerging Water Technology Symposium, Dr. Janet Stout, a noted infectious disease microbiologist from the University of Pittsburgh, answered a question related to the setting of water heaters by saying 140 °F should be the minimum temperature. They state that if that is the case, the assumed 95 percent water heater may in reality be no better than 87 to 88 percent most of the time. It is unclear if the proposed rule makes any allowance for this situation, but it will have a large impact on the projected energy savings. (PHCC, No. 28 at p. 3)

NYSERDA supports DOE's analytical approaches for temperature settings and DOE's acknowledgement that in the real world multiple setpoints are used. (NYSERDA, No. 30 at p. 2)

Bradford White noted that in the analysis for circulating water heaters, DOE assumed a storage tank size of 250 to 350 gallons. While this overall size can be used, Bradford White noted that this is highly dependent on the application that the product is installed in. Also, if too much storage is used in the wrong application, it can lead to condensing where you do not want it. (Bradford White, No. 23 at p. 9). CA IOUs noted a water heating system is often composed of multiple hot water sources and separate hot water storage tanks. Separate hot water systems are usually needed to meet the primary make-up load, hot water load, and the secondary recirculating hot water loop load. Therefore, in future analysis, the CA IOUs recommend that DOE consider the interplay of these components when assessing heat pump water heaters. (CA IOUs, No. 33 at pp. 2–3)

In response to PHCC, DOE recognizes that there is debate over water heater set points and concern with legionella growth in hot water systems, and there have been different approaches in practice regarding set points and controls for CWH systems. DOE agrees with comments by NYSERDA that, in practice, there will be some range of set points used. DOE also reiterates that that the federal test procedure for commercial gas storage water heaters and commercial gas instantaneous water heaters rates the thermal efficiency of these products at a flow rate that provides for essentially a 140 °F outlet temperature and to provide for that in practice, the setpoint is set approximately at that temperature. While DOE is cognizant of the concerns raised by PHCC, DOE does not believe that a recommendation to use setpoints near but above 140 °F will result in the dramatic change in thermal efficiency indicated by PHCC. As previously stated, DOE believes that, for current condensing water heater designs, it is inlet temperature that will have a bigger effect on efficiency and more attention may need to be paid to modulating heat capability and how inlet water is introduced to systems with recirculation. Regarding the Bradford White observation on storage tank sizing, DOE reviewed equipment manuals to try to establish a reasonable range of storage tank sizes that would be typical selections for the representative circulating water heaters and hot water supply boilers units input rate developed unit from the engineering analysis. The range of storage tank sizes was the same as was used in the withdrawn May 2016 CWH ECS NOPR and DOE did not receive comment on how it could improve this selection. DOE appreciates the comment that there may be engineering aspects to the use of larger storage tanks but believes that its selection of this size range was prudent for the representative equipment input rate based on manufacturer literature reviewed. In a similar vein, DOE appreciates the comment from CA IOUs in terms of their understanding of the use of multiple and types of CWH equipment in developing commercial hot water systems and their comment that DOE should consider the interplay among these components when assessing heat pump water heaters. DOE did not consider energy conservation standards for commercial heat pump water heaters in this final rule because of the limited number of units on the market. However, DOE may analyze standards for commercial heat pump water heaters in a future rulemaking, at which time DOE will consider how to address the interplay among these different components in evaluating standards including commercial heat pump 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 CWH equipment. 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 equipment over the life of that equipment, 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 equipment.

- 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 type of equipment 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 CWH equipment 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 equipment.

DOE conducted the LCC and PBP analyses using a commercially available spreadsheet tool and a purpose-built spreadsheet model, available on DOE's website.[63]

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[63] DOE's webpage for CWH equipment is available at www1.eere.energy.gov/buildings/appliance_standards/standards.aspx?productid=36. Last accessed on December 15, 2022.

This spreadsheet model developed by DOE accounts for variability in energy use and prices, installation costs, repair and maintenance costs, and energy costs. As a result, the LCC results are also displayed as distributions of impacts compared to the no-new-standards-case (without amended standards) conditions. The results of DOE's LCC and PBP analysis are summarized in section V.B.1.a of this final rule and described in detail in chapter 8 of the final rule TSD.

As previously noted, DOE's LCC and PBP analyses generate values that calculate the PBP for consumers of potential energy conservation standards, which includes, but is not limited to, the 3-year PBP contemplated under the rebuttable presumption test. However, DOE routinely conducts a full economic analysis that considers the full range of impacts, including those to the consumer, manufacturer, Nation, and environment, as required under 42 U.S.C. 6313(a)(6)(ii). The results of this analysis serve as the basis for DOE to evaluate the economic justification for a potential standard level (thereby supporting or rebutting the results of any preliminary determination of economic justification).

DOE expressed the LCC and PBP results for CWH equipment on a single, per-unit basis, and developed these results for each thermal efficiency and standby loss level, or UEF level, as appropriate. In addition, DOE reported the LCC results by the percentage of CWH equipment consumers experiencing negative economic impacts (*i.e.*, LCC savings of less than 0, indicating net cost).

DOE modeled uncertainty for specific inputs to the LCC and PBP analysis by using Monte Carlo simulation coupled with the corresponding probability distributions, including distributions describing efficiency of units shipped in the no-new-standards case. The Monte Carlo simulations randomly sample input values from the probability distributions and CWH equipment user samples. For this rulemaking, the Monte Carlo approach is implemented in MS Excel together with the Crystal Ball™ add-on.[64] Then, the model calculated the LCC and PBP for equipment at each efficiency level for the 10,000 simulations using the sampled inputs. More details on the incorporation of uncertainty and variability in the LCC are available in appendix 8B of the final rule TSD.

For the May 2022 CWH ECS NOPR, DOE analyzed the potential for variability by performing the LCC and PBP calculations on a nationally representative sample of individual commercial and residential buildings. This same general process was used for this final rule analysis, however, with updates to the data set. One update was switching to CBECS 2018 consistent with DOE's general practice of relying on updated data sources to the extent practicable and appropriate.[65] The CBECS 2018 microdata needed for its analysis were not available when DOE conducted the May 2022 CWH ECS NOPR analysis; hence, DOE used CBECS 2012 (the most recent available version at the time) for the 2022 CWH ECS NOPR analysis. In this final rule, DOE updated its LCC model to use EIA's CBECS 2018 microdata.

[64] 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/middleware/technologies/crystalball/* (last accessed December 15, 2022).
[65] More information on the types of buildings considered is discussed later in this section. CBECS: *www.eia.gov/consumption/commercial/data/2018/*. Link last accessed on December 15, 2022.

Following is a discussion of the development and validation of DOE's LCC model. Across its energy conservation standards rulemakings, DOE incorporates tools that enable stakeholders to reproduce DOE's published rulemaking results. DOE routinely utilizes Monte Carlo simulations using Crystal Ball for LCC model simulation purposes. More specifically, utilizing a spreadsheet program with Crystal Ball enables DOE to test the combined variability in different input parameters on the final life-cycle performance of the equipment. The CWH LCC model specifically includes macros to run the standards analysis with default settings that enable stakeholders to download the LCC model, run it on their own computers, and reproduce results published in this final rule.[66] To validate models, DOE develops models with contractors familiar with Crystal Ball and Monte Carlo tools and other models generally, and regularly tests the models during development, both at average and atypical (extreme) conditions. DOE further notes that the LCC model using the Crystal Ball software can output the assumed values and results of each assumption and provide forecasted results for each iteration in the Monte Carlo simulation, if desired by stakeholders to review or trace the output. In addition, it is possible to directly modify the assumption cells in the model to examine impacts of changes to assumptions on the LCC, and, in fact, DOE relies on both of these techniques for model testing.[67] DOE additionally seeks expert validation by going through a comprehensive stakeholder review of the assumptions and making its models and TSD publicly available during the comment period during each phase of its

[66] To reiterate, DOE's webpage for CWH equipment is available at www1.eere.energy.gov/buildings/appliance_standards/standards.aspx?productid=36.

[67] The model being discussed in this section, the LCC, has no known locked cells and it is unprotected, meaning all cells are available for editing by users as stated in the text. DOE does in some cases lock cells and worksheets in order to protect proprietary data. Such is not the case with the LCC model used in this rulemaking, so users should be able to edit assumptions in this model.

regulatory proceedings. DOE uses the Monte Carlo models for predicting the impact of future standards, a use different than many other uses that are envisioned generally for Monte Carlo tools (like industrial process examination), so direct validation against data demonstrating the impact of future standards is not possible. With regard to specifying correlations between inputs as part of modeling practices, DOE notes that while one can specify correlation parameters between two variables where such correlation and the data to provide for the level of correlation are known, specifying such correlations is not necessary to maintain the general integrity and accuracy of the analytical framework. Variable values may be selected based on other coding decisions unique to each iteration (*e.g.*, correlation with building type or location or vintage) without specific reference to correlation variables, and DOE does this routinely. For instance, entering water temperature and fuel costs are effectively correlated based on data and the use of the geographic region, which impacts both through the available data or models. The use of explicit correlations between Crystal Ball variables, where data are available to determine or represent a degree of correlation, absent other influences, would be useful, but often, DOE's experience is that the data to express the degree of correlation are not available and are influenced by other factors already dealt with explicitly in the model framework.

DOE calculated the LCC and PBP for all consumers as if each would purchase a new CWH unit in the year that compliance with amended standards is required. As previously discussed, DOE is conducting this rulemaking pursuant to its 6-year-lookback authority under 42 U.S.C. 6313(a)(6)(C). At the time of preparation of the final rule analyses, the anticipated final rule publication date was 2023. Thus, for the purposes of the LCC modeling DOE relied on 2023 as the expected publication date of a final rule.

EPCA states that amended standards prescribed under this subsection shall apply to equipment manufactured after a date that is the later of (I) the date that is 3 years after publication of the final rule establishing a new standard or (II) the date that is 6 years after the effective date of the current standard for a covered equipment. (42 U.S.C. 6313(a)(6)(C)(iv)) Therefore, for the purposes of its LCC analysis for this final rule, DOE used January 1, 2026 as the beginning of compliance with potential amended standards for CWH equipment.

Recognizing that each consumer that uses CWH equipment is unique, DOE analyzed variability and uncertainty by performing the LCC and PBP calculations on a nationally representative stock of commercial and residential buildings. Commercial buildings can be categorized based on their specific activity, and DOE considered commercial buildings such as offices (small, medium, and large), stand-alone retail and strip-malls, schools (primary and secondary), hospitals and outpatient healthcare facilities, hotels (small and large), warehouses, restaurants (quick service and full service), assemblies, nursing homes, and dormitories. These encompass 93 percent of the total sample of commercial building stock in the United States. The residential buildings can be categorized based on the type of housing unit, and DOE considered single-family (attached and detached) and multi-family (with 2–4 units and 5+ units) buildings in its analysis. This encompassed 95.5 percent of the total sample of residential building stock in the United States, though not all of this sample would use CWH equipment. DOE developed financial data appropriate for the consumers in each business and building type. Each type of building has typical consumers who have different costs of financing because of the nature of the business. DOE derived the financing costs based on data from the Damodaran Online website.[68] For residential applications, the entire household population was categorized into six income bins, and DOE developed the probability distribution of real interest rates for each income bin by using data from the Federal Reserve Board's Survey of Consumer Finances.[69]

The LCC analysis used the estimated annual energy use for each CWH equipment category described in section IV.C of this final rule. Aside from energy use, other important factors influencing the LCC and PBP analyses are energy prices, installation costs, and equipment distribution markups. At the national level, the LCC spreadsheets explicitly model both the uncertainty and the variability in the model's inputs, using probability distribution functions.

As mentioned earlier, DOE generated LCC and PBP results for individual CWH consumers, using business type data aligned with building type and by geographic location, and DOE developed weighting factors to generate national average LCC savings and PBPs for each efficiency level. As there is a unique LCC and PBP for each calculated combination of building type and geographic location, the outcomes of the analysis can also be expressed as probability distributions with a range of LCC and PBP results. A distinct advantage of this type of approach is that DOE can identify the percentage of consumers achieving LCC savings or attaining certain PBP values due to

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[68] *Damodaran Online*. Commercial Applications. Available at *pages.stern.nyu.edu/~adamodar/New_Home_Page/home.htm*. Last accessed on December 16, 2022.

[69] The real interest rates data for the six income groups (residential sector) were estimated using data from the Federal Reserve Board's Survey of Consumer Finances (1989, 1992, 1995, 1998, 2001, 2004, 2007, 2010, 2013, 2016, and 2019). Available at *www.federalreserve.gov/pubs/oss/oss2/scfindex.html*. Last accessed on December 16, 2022.

an increased efficiency level, in addition to the average LCC savings or average PBP for that efficiency level.

DOE calculates energy savings for the LCC and PBP analysis using only onsite electricity and natural gas usage. For determination of consumer cost savings, the onsite electricity and natural gas usage are estimated separately with appropriate electricity and natural gas prices, or marginal prices, applied to each. Primary and FFC energy savings are not used in the LCC analysis.

For each efficiency level that DOE analyzed, the LCC analysis required input data for the total installed cost of the equipment, its operating cost, and the discount rate. Table IV.19 summarizes the inputs and key assumptions DOE used to calculate the consumer economic impacts of all energy efficiency levels analyzed in this rulemaking. A more detailed discussion of the inputs follows.

Table IV.19 Summary of Inputs and Key Assumptions Used in the LCC and PBP Analyses

Inputs	Description
Affecting Installed Costs	
Product Cost	Derived by multiplying manufacturer sales price or MSP (calculated in the engineering analysis) by distribution channel markups, as needed, plus sales tax from the markups analysis.
Installation Cost	Installation cost includes installation labor, installer overhead, and any miscellaneous materials and parts, derived principally from RSMeans 2018 through 2022 data books[A,B,C] and converted to 2022$.
Affecting Operating Costs	
Annual Energy Use	Annual unit energy consumption for each class of equipment at each efficiency and standby loss level estimated at different locations and by building type using building-specific load models and a population-based mapping of climate locations. The geographic scale used for commercial and residential applications are Census Divisions and reportable domains respectively.

Inputs	Description
Electricity Prices, Natural Gas Prices	DOE developed average residential and commercial electricity prices based on EIA Form 861M, using data for 2022.[D] Future electricity prices are projected based on *AEO2023*. DOE developed residential and commercial natural gas prices based on EIA State-level prices in EIA Natural Gas Navigator, using data for 2022.[E] Future natural gas prices are projected based on *AEO2023*.
Maintenance Cost	Annual maintenance cost did not vary as a function of efficiency.
Repair Cost	DOE determined that the materials portion of the repair costs for gas-fired equipment changes with the efficiency level for products. The different combustion systems varied among different efficiency levels, which eventually led to different repair costs.
Affecting Present Value of Annual Operating Cost Savings	
Product Lifetime	Table IV.21 provides lifetime estimates by equipment category. DOE estimated that the average CWH equipment lifetimes range between 10 and 25 years, with the average lifespan dependent on equipment category based on estimates cited in available literature.[F]
Discount Rate	Mean real discount rates (weighted) for all buildings range from 3.2% to 5.0%, for the six income bins relevant to residential applications. For commercial applications, DOE considered mean real discount rates (weighted) from 10 different commercial sectors, and the rates ranged between 3.2% and 7.2%.
Analysis Start Year	Start year for LCC is 2026, which would be the anticipated compliance year for adopted standards.
Analyzed Efficiency Levels	
Analyzed Efficiency Levels	DOE analyzed baseline efficiency levels and up to five higher thermal efficiency levels for commercial gas-fired storage water heaters, commercial gas-fired tankless water heaters, and commercial gas-fired instantaneous circulating water heaters and hot water supply boilers. For residential-duty gas-fired storage, DOE analyzed baseline and up to five higher UEF levels which combine thermal efficiency and standby loss improvements. See the engineering analysis for additional details on selections of efficiency levels and costs.

[A] RSMeans. 2017 through 2022 Plumbing Costs with RSMeans Data. RSMeans data available at *www.rsmeans.com/products/books*, though when last accessed, the 2022 books no longer appeared to be available.
[B] RSMeans. 2022 Facilities Maintenance & Repair Costs with RSMeans Data. RSMeans data available at *www.rsmeans.com/products/books*.
[C] RSMeans. Estimating Costs with RSMeans Data, CostWorks CD, Mechanical Costs for 2021 and 2022, and 2018 through 2020 Mechanical Cost with RSMeans Data. Available *www.rsmeans.com/2022-mechanical-cost-data-cd.* RSMeans links last accessed on April 19, 2023.
[D] U.S. Energy Information Administration (EIA). Average Retail Price of Electricity (Form EIA-861M). Available at *www.eia.gov/electricity/data.php*. Last accessed on March 31, 2023.
[E] U.S. Energy Information Administration (EIA). Average Price of Natural Gas Sold to Commercial Consumers - by State. Available at *www.eia.gov/dnav/ng/ng_pri_sum_a_EPG0_PCS_DMcf_a.htm.* Prices for Residential Consumers are available at the same site using the Data Series menu. EIA data last updated March 31, 2023, and accessed on March 31, 2023.
[F] American Society of Heating, Refrigerating, and Air-Conditioning Engineers. 2011 ASHRAE Handbook: Heating, Ventilating, and Air-Conditioning Applications. 2011. Available at *www.ashrae.org/resources--publications*. Last accessed on October 16, 2016.

In response to the May 2022 CWH ECS NOPR, DOE received numerous general comments related to the LCC and PBP analysis. Atmos Energy and Joint Gas Commenters state that DOE should break storage and instantaneous water heaters out separately for purposes of LCC and PBP analysis. (Atmos Energy, No. 36 at pp. 4–5; Joint Gas Commenters, No. 34 at p. 33) In section III.B.6, DOE discusses the determination that commercial gas-fired storage water heaters and storage-type gas-fired instantaneous water heaters would be treated jointly for purposes of the final rule. Because they are being treated jointly, modeling them separately in the LCC and PBP analysis was seen as confusing and unnecessary.

As noted in section IV.E, many commenters said DOE should update to more recent RECS and CBECS data. CA IOUs indicated support for DOE's proposed minimum efficiency standards if DOE updated the analyses with newer data including specifically the more recent CBECS and RSMeans data. AHRI stated their concern about DOE is using older CBECS and RECS data which they termed "outdated data," and that this could cause DOE to underestimate the true impacts to consumers. AHRI recommended that DOE conduct updated analysis where existing data sources are out of date. (CA IOUs, No. 33 at p. 1; AHRI, No. 31 at p. 2) DOE acknowledges the CA IOUs and AHRI comments and notes that the LCC and PBP analysis has been updated to include the 2018 CBECS, but as discussed in section IV.E, DOE maintained use of the 2009 RECS.

PHCC believes that the economic analysis has several deficient factors and as a result it would be difficult to rely on the projected energy savings, cost of materials, labor costs and times presented by DOE to do certain aspects of the work. PHCC encourages DOE to update the basic information in the LCC model to reflect current 2022 conditions in the marketplace. (PHCC, No. 28 at pp. 10–11) As discussed in the subsections below, DOE has updated a large number of the inputs used in the LCC and PBP analyses. Some inputs such as the U.S. Economic Census underlying the Markups Analysis cannot be updated because the 2017 census remains the most recent census.

Patterson-Kelley stated concerns that the methodology to generate the RECS and CBECS data sets marginalizes large portions of the country. (Patterson-Kelley, No. 26 at p. 2) WM Technologies expressed a similar concern adding the data exhibit a bias toward larger revenue generating areas and larger buildings. By doing so they believe CBECS exhibits an unrecognized bias against underserved communities and populations. Buildings and homes in rural and lower revenue areas typically have less insulation while larger cities typically have more exacting building codes and enforcement. Therefore, the current CBECS approach also erroneously minimizes actual variation in the LCC results, with the largest errors in the impact to disadvantaged and underserved communities and small businesses. WM Technologies also called on DOE to provide the impact to the results from using different sources of information than RECS and CBECS and provide realistic modeling by accounting for documented uncertainties and variation to the inputs used in the analysis. (WM Technologies, No. 25, at pp. 4–5) Patterson-Kelley and WM Technologies stated that any LCC modeling must include the variation in the CBECS and RECS data sets, consistently relating to all references to the location-specific information of the home or building modeled as this will better utilize the variation and energy usage on average, identified in the national energy surveys noted in the 2015 RECS comparison with other studies. (Patterson-Kelly, No. 26, at pp. 2, 4; WM Technologies, No. 25 at p. 4–5) DOE disagrees with the conclusions reached in WM Technologies' and Patterson-Kelley's comments, as was pointed out in section III.E in which DOE addressed the majority of WM Technologies and Patterson-Kelley's comment. CBECS and RECS datasets are nationally representative datasets available for public use. Since the commenters did not suggest specific different sources of information when calling on DOE to provide the impacts from using different sources of information, this suggestion seems to not be feasible to DOE. DOE agrees that the EIA sampled major cities with certainty as stated by WM Technologies and Patterson-Kelly, but questions whether electing to not take the chance that a major commercial hub like Chicago would be excluded from CBECS samples due to pure random chance in the sampling selection represents bias as alleged in these comments. Regardless, at the end of the process EIA assigns weights to buildings. So, a large building in downtown New York City receives a low building weight because there are very few such buildings, while smaller buildings characteristic of rural areas get much higher weights because there are large numbers of them across the country.

The Joint Gas Commenters offered several reactions to DOE's discussion of LCC and claimed that they overall believe the standards are not economically justified nor supported by clear and convincing evidence. Firstly, they stated that DOE's LCC results shows that consumers barely break even with LCC savings ranging from 0.58 to 1.25 percent of total LCC. They further offered their opinion that because DOE has addressed some variability of inputs in the model but has not addressed all uncertainties about the ranges and distributions of inputs to the model, the proposed standards could impose net costs, and that this does not provide the clear and convincing evidence needed to amend the standards. (Joint Gas Commenters, No. 34 at pp. 14–15) Additionally, they noted that DOE performed the analysis by building up to the price that consumers pay for products and their installation and related costs, rather than collecting “actual” data. They pointed to assumptions made and offered their opinion that DOE must locate suitable data, and lacking such, must resolve against amending the standards. (Joint Gas Commenters, No. 34 at pp. 16–17) In response, DOE addresses similar “clear and convincing evidence” comments in section III.A of this document.

DOE notes that the LCC savings presented in the 2022 CWH ECS NOPR represent an overall average, reflecting the fractions of consumers that are better off and that are worse off due to the proposed standard, as well as a significant percentage of consumers for whom the standard has no effect because they already purchase equipment that meet the standard. In this final rule, the LCC savings represent an average of the affected consumers only, excluding those for whom the standard has no effect. The LCC savings in the final rule also reflect changes DOE has made to address comments received on the NOPR. For example, given stakeholder comments on the withdrawn 2016 CWH ECS NOPR that there may be consumer with extraordinary installation costs, the 2022 CWH ECS NOPR introduced an extraordinary cost factor which resulted in increased installation costs by a factor from 200 to 300 percent for a small percentage of customers. For the 2022 CWH ECS NOPR that percentage of consumers was 2 percent, a figure that DOE retained in the final rule analysis. In the final rule analysis, DOE has increased the fraction of consumers that install condensate pumps and increased the fractions of consumers installing condensate neutralizers. In addition, DOE updated the installation costs and venting materials costs based on the most current available data. These changes and other are discussed in IV.F.2 of this document.

DOE notes that while Joint Gas Commenters are correct that the relative LCC savings may be small, DOE considers other factors when assessing whether there is clear and convincing evidence that a standard is economically justified, such as PBP and the NIA. For example, a major reason for the small LCC savings is the cost of associated venting (discussed more in section IV.F.2 of this document). However, DOE believes it reasonable to assume that once the venting has been installed, it will also be usable in the future when the CWH equipment is replaced. This benefit is captured in the longer-term NIA, which includes replacement of water heaters as they reach the end of their useful life. However, DOE did not capture the residual value of the venting system in the LCC analysis as the LCC analysis ends at the end of the useful life of the CWH unit. Moreover, DOE notes that, for each equipment type, the simple payback period is shorter than the equipment life, particularly for the instantaneous products where the payback period is approximately half of the expected equipment lifetime. So, while Joint Gas Commenters are correct that the relative LCC savings may be small due to the standard, that fact alone is not the end of DOE's economic justification analysis. Further discussion of the results of all of DOE's economic analyses and DOE's conclusions may be found in section V of this document.

DOE disagrees that there are unresolved uncertainties, and has determined the issues raised in comments on the May 2022 CWH ECS NOPR have been sufficiently addressed to resolve any alleged uncertainties. As for whether "building up costs" is a reasonable approach, DOE relied primarily on data from RSMeans and other nationally recognized sources to develop its cost analyses. These resources provided itemized data at each step of the process and in particular to the LCC discussions, on the installation and removal costs of both equipment and venting systems, as well as the installation costs of condensate drainage systems, electrical outlets, and chimney relining. The itemization of these costs was at the component level for both labor and material, and in both the commercial and residential sectors, which allowed DOE to develop an appropriate set of installation scenarios to factor into the lifecycle cost analysis. The use of these resources also provided DOE with a consistent evaluation of costs with a consistent set of location adjustments for each residential and commercial region included in the analysis. For these reasons, DOE believes the sources relied upon were valid and appropriate for the development of installed equipment costs. Moreover, DOE notes that surveys of existing contractor quotes may not adequately separate equipment costs from installation costs since installing contractors would commonly be selling and marking up equipment as well as installation labor. DOE has observed that contractor quotes are often lump sum prices and getting contractors to disaggregate such prices has historically been difficult. Thus, use of surveys would not provide the level of detailed information needed to assess installation costs.

1. Equipment Cost

To calculate consumer equipment costs, DOE multiplied the MSCs developed in the engineering analysis by the markups described previously (along with sales taxes) in section IV.D of this document. DOE used different markups for baseline equipment and higher-efficiency equipment because DOE applies an incremental markup to the increase in MSP associated with higher-efficiency products. For each equipment category, the engineering analysis provided equipment costs for the baseline equipment and up to five higher equipment efficiencies. For the withdrawn 2016 CWH ECS NOPR, DOE examined whether available data suggested that equipment costs for CWH equipment would change over time in constant real dollar terms, indicating the potential for a "learning" or "experience" curve in equipment prices that might indicate further reductions in equipment price might be expected. In the data reviewed, DOE did not identify a clear long term historical price trend for CWH equipment.. As DOE has seen no direct evidence to overturn that earlier decision, DOE used costs established in the engineering analysis directly for determining 2026 equipment costs and future equipment costs (equipment is purchased by the consumer during the first year in 2026 at the estimated equipment price, after which the equipment price remains constant in real dollars). See chapter 10 of the final rule TSD for more details.

The markup is the percentage increase in cost as the CWH equipment passes through distribution channels. As explained in section IV.D of this final rule, CWH equipment is assumed to be delivered by the manufacturer through a variety of distribution channels. There are several distribution pathways that involve different combinations of the costs and markups of CWH equipment. The overall resulting markups in the LCC analysis are weighted averages of all of the relevant distribution channel markups.

2. Installation Cost

Installation cost includes labor, overhead, and any miscellaneous materials and parts needed to install the CWH equipment. Total installed cost includes the retail cost of the CWH equipment and its corresponding installation costs. Installation costs vary by efficiency level, primarily due to venting costs. For new construction installations, the installation cost is added to the equipment cost to arrive at a total installed cost. For replacement installations, the costs to remove the previous equipment (including venting when necessary) and the installation costs for new equipment, including venting and additional expenses, are added to the product cost to arrive at the total replacement installation cost.

DOE derived national average installation costs for commercial equipment from data provided in RSMeans data books.[70] RSMeans provides estimates for installation costs for CWH units by equipment capacity, as well as cost indices that reflect the variation in installation costs for 295 cities in the United States. The RSMeans data identify several cities in each of the 50 States, as well as the District of Columbia. DOE incorporated location-based cost indices into the analysis to capture variation in installation costs, depending on the location of the consumer. Based upon the RSMeans data, relationships were developed for each product subcategory to relate the amount of labor to the size of the product—either the storage volume or the input rate. Generally, the RSMeans data were in agreement with other national sources, such as the Whitestone Facility Maintenance and Repair Cost Reference.[71]

DOE calculated venting costs for each building in the CBECS and RECS. A variety of installation parameters impact venting costs; among these, DOE simulated the type of installation (new construction or retrofit), water heater type, draft type

[70] DOE notes that RSMeans publishes data books in November or December for use the following year; hence, the 2022 data book has a 2021 copyright date.
[71] Whitestone Research. The Whitestone Facility Maintenance and Repair Cost Reference 2012-2013 (17th Annual edition). 2012. Whitestone Research: Santa Barbara, CA.

(atmospheric venting or power venting), building vintage, number of stories, and presence of a chimney. A combination of Crystal Ball variable distributions and Microsoft Excel macros and spreadsheet calculations are used to address the identified variables to determine the venting costs for each instance of equipment for each building within the Monte Carlo analysis. With regard to the venting material for condensing equipment, the primary assumptions used in this logic are listed as follows:

- 25 percent of commercial buildings built prior to 1980 were assumed to have a masonry chimney, and 25 percent of masonry chimneys required relining.

- Condensing equipment with vent diameters smaller than 5 inches were modeled using PVC (polyvinyl chloride) as the vent material.

- Condensing equipment with vent diameters of 8 inches or greater were assigned AL29-4C (superferritic stainless steel) as the vent material.

- Condensing equipment with vent diameters of 5 inches and up to 8 inches were assigned vent material based on a random selection process in which, on average, 50 percent of installations received PVC as the vent material and the remaining received AL29-4C.

- 5 percent of all condensing CWH equipment installations were modeled as direct vent installations. The intake air pipe material for condensing products was modeled as PVC.

Additional details of the venting logic sequence are found in chapter 8 and appendix 8D of the final rule TSD.

a. Data Sources

For this final rule analysis, DOE used the most recent datasets available at the time the analysis was conducted. DOE routinely updates data to the most recent datasets available at its various rulemaking stages and has updated the CWH equipment LCC model with the most recent data estimates available for this final rule, including use of the 2018 CBECs and 2022 RSMeans data (including 2022 RSMeans Plumbing Costs Data, 2022 RSMeans Mechanical Cost Data, and 2022 RSMeans Facility Maintenance and Repair Costs). In reviewing the 2022 RSMeans cost books, DOE noted a rapid escalation of prices from 2021 to 2022 for installation materials including PVC pipes and related connectors and hangers, Type B venting and associated materials, and stainless steel. The 2022 escalation in these prices relative to 2021 exceeded the escalation seen in previous years' prices. DOE believes the 2022 escalation is related to the Covid-19 pandemic and the supply chain bottleneck arising during the pandemic. Because these input materials are generally undifferentiated between manufacturers and subject to supply and demand forces much like other construction materials like lumber or commodities such as steel, DOE believes that prices will eventually revert to something akin to historical trends. To capture prices more consistent with long-term escalation trends, DOE used a 5-year average of prices for PVC and Type B venting and related components, and for Series 300 stainless steel venting materials derived from RSMeans 2018 through 2022 data books. For AL29-4C stainless steel, DOE had access to 4 years of data from the source that DOE has used in this rulemaking, for the years 2018 and

2020 through 2022. For AL29-4C, DOE used an average of these 4 years. For the RSMeans data and the AL29-4C data, all prices not originally denominated in 2022$ were inflated to 2022$ using the GDP Implicit Price Deflator.

Bradford White disagreed that installation or removal cost does not vary with thermal efficiency as more efficient products are typically heavier than their less efficient counterparts. They stated this translates into more people and/or equipment being required to position the new water heater, which will drive up installation costs. Bradford White also noted that condensate removal must be accounted for at condensing levels. Bradford White also suggested that equipment costs will influence installation costs, although that may not be detailed as such on the invoice. (Bradford White, No. 23 at p. 8)

DOE, in response to Bradford White's comments, notes that it did not explore relative weights between non-condensing and condensing equipment of the same capacity but notes that the data sources used by DOE indicated installation labor was a function of the input rating of the equipment which will in turn determine the size (dimensions) of the equipment. DOE based the labor assumption on the input rates of the representative models, and because the input rate does not change by EL, DOE's estimated labor also does not change by EL. Commercial water heaters are generally large and already require multiple persons during the installation, and DOE believes the size differences between ELs would generally be small enough to be unlikely to impact the number of people needed to install or remove equipment. DOE agrees that condensate disposal is a factor leading to differing installation costs, and addresses the cost of condensate removal in IV.F.2.b of this document. To the extent that a contractor bases the installation cost on equipment costs, the contractor is likely applying a markup to the equipment to recover their own costs. DOE does include contractor markups in the determination of retail price as well as markups embedded in other inputs to the process such as the labor costs. Beyond that, DOE was not provided with sufficiently specific data for DOE to assess whether there is basis on which to account for such markups.

Bradford White stated the labor rate DOE used for the commercial sector used, at $89 per hour, is in their opinion more representative of the top end of the residential sector labor rates, and commercial sector rates are in excess of $125 per hour. They also stated DOE is correct that regional adjustments need to be made to this value, but the low end for North and South Carolina is too low at 0.59. (Bradford White, No. 23 at p. 8) PHCC also believes that the labor rates used by DOE are significantly understated. PHCC notes that the U.S. Department of Labor ("DOL") publishes information about prevailing wage rates for localities across the country, and the Biden Administration through DOL has made efforts to expand the use of such information in hopes of promoting fair and equitable employment opportunities. It would seem that using this information would align with the goals of the Biden Administration through DOE as well, PHCC stated. PHCC does express concern that the labor assumptions made by DOE are outdated, that the labor market has changed post COVID-19 with worker shortages driving up pay and benefits and that DOE should evaluate its assumptions. PHCC provided to DOE a sample table of commercial building plumber rates, with employer costs and markups for each state as an example to DOE, with a resulting average cost of $106/hr. While the sample table PHCC provided used a random county in each state, PHCC notes that a weighted scheme should be incorporated to accurately gauge state averages as plumber rates in high population areas would apply to a greater fraction of the population or sales. (PHCC, No. 28 at p. 10) DOE acknowledges the information provided by Bradford White and PHCC, and notes that the data source used by DOE for labor rates and for the regional indexes is a nationally recognized source for labor rates. Using the regional adjustment factors for individual states, four states meet or exceed Bradford White's $125 value. The state factors developed by DOE are a weighted average of individual city rates. Thus, depending on where Bradford White observed the rates they are citing, they are well within the range used by DOE. Additionally, DOE's regional multipliers for North and South Carolina are consistent with other southern states. With respect to PHCC's suggestion about the prevailing wage, DOE uses the RSMeans values because they are from a nationally recognized source, collected by surveys. With this in mind, DOE elected to continue to use RSMeans data with the only change being to update to the current RSMeans values available when the analysis was performed.

Joint Gas Commenters stated that labor costs for CWH replacements are typically not standard rates but are premium rates due to overnight hours. Joint Gas Commenters also stated DOE inadequately accounted for uncertainty about labor costs. (Joint Gas Commenters, No. 23, at pp. 14 and 18) In response, while Joint Gas Commenters suggested that labor costs for CWH replacements are typically not standard rates, they did not provide data to support this. DOE is aware that some businesses that rely on water heaters for production (*e.g.*, food service) might opt for a night replacement. However, many other building types (offices, retail, schools) can and do readily make changes such as replacing water heaters during the day as the outage, while inconvenient, does not limit operations. Two other large users are hotels and health care facilities. All hotels and many health care facilities (*e.g.*, hospitals) are already 24/7 facilities, and it is unclear that an over-night water heater replacement is an improvement over a day-time replacement from the viewpoint of providing for hot water. Many of these facilities rely on multiple water heater plants so hot water can be available at some level if problems arise with a given unit (as is pointed out later by the Joint Gas Commenters in their comments). DOE believes many larger food service business may do the same and where they do not use multiple water heaters, both non-condensing and condensing units may be replaced at night (*i.e.*, efficiency of the units is not particularly relevant to timing of installation). Further, most food service buildings are relatively small low rise one or two-story buildings commonly with the water heater associated with the kitchen space and typically on a separate, outside portion from the dining space and with floor drains already in close proximity. This minimizes or eliminates factors potentially leading to difficult installations, namely, most food service buildings will not be many-storied buildings with difficult vertical venting installations and in fact many may be able to use less costly and simpler horizontal venting. In addition, where water heaters are installed in commercial kitchen areas, floor drains will typically exist already for code and safety reasons. DOE believes that installation of condensing water heater venting may in fact be less difficult for food service buildings than in other buildings, meaning that the installation time will be more manageable. To the extent the replacement needs to take place at night, such would occur regardless of the efficiency of the equipment.

Accordingly, for the final rule, DOE did not apply any factor to increase the labor costs above what was available in RSMeans.

b. Condensate Removal and Disposal

In the May 2022 CWH ECS NOPR, DOE based assumptions concerning the need for condensate removal and disposal in part on DOE's understanding of the International Plumbing Code.[72] The International Plumbing Code calls for temperature and pressure relief valves to be piped to drain, which means that non-condensing CWH equipment should already have an existing drainage system. An additional factor underlying DOE's assumptions is the fact that a condensate neutralizer is not required in certain jurisdictions, though it is good design practice.

In response to these underlying factors the May 2022 CWH ECS NOPR analysis assumed a condensate neutralizer was assigned to 12.5 percent of replacement installations (which was unchanged from the assumption used in the withdrawn May 2016 CWH ECS NOPR). The cost of heat tape was assigned to 10 percent of replacement installations, and the cost of an electrical outlet specifically for heat tape was added for 10 percent of instances in which heat tape was installed.

JJM Alkaline stated that DOE's assumption of 12.5 percent of water heater installations needing condensate neutralizers for condensing equipment is too low, noting that the U.S. Environmental Protection Agency ("EPA") and many municipalities have

[72] See *www.iccsafe.org/content/international-plumbing-code-ipc-home-page/*. The model International Plumbing Code has been adopted 35 states for state or local plumbing codes.

codes regarding acidic condensate discharge into public works and the acidic condensate from heating appliances is generally 2.9 to 4.0 pH, which is below the threshold of 5.0 pH. (JJM Alkaline, No. 10 at p. 1) Bradford White recommended increasing the percentage of installations that utilize a condensate neutralizer, stating that for installations that are over 200,000 Btu/hr, the percentage is closer to 75 percent (because those installations are more likely to be inspected due to pressure vessel requirements) while for installations under 200,000 Btu/hr, the percentage is above the estimated 12.5 percent and growing. (Bradford White, No. 23 at p. 8)

Regarding the comments on the use of condensate neutralizers from JJM Alkaline and Bradford White, DOE reviewed the applicable IPC[73] and Uniform Plumbing Code ("UPC")[74] as the two most widely used model plumbing codes in the United States. Both documents have relevant sections. The IPC requirement (IPC 2019 section 803.2) is titled "Neutralizing device required for corrosive wastes" and is a more general requirement for "Corrosive liquids, spent acids or other harmful chemicals that destroy or injure drain, sewer, soil or waste piping, or create noxious or toxic fumes or interfere with sewage treatment processes." Where such harmful chemicals exist (as determined by the authority having jurisdiction), the IPC requires such corrosive wastes to be diluted or neutralized using an "*approved*" dilution or a neutralizing device. The UPC (UPC 2021 803.2) by contrast refers specifically to condensate from fuel burning condensing appliances, and where such condensate is discharged into a drain, the material in the

[73] International Code Council. 2018 International Plumbing Code (IPC). Available from *www.iccsafe.org*.
[74] International Association of Plumbing & Mechanical Officials (IAMPO). 2021 Uniform Plumbing Code. Available from *iapmo.org*.

drainage system must be cast-iron, galvanized iron, plastic, or other material approved for this use. DOE examination of these suggests that the IPC and similar local code requirements would be more likely to result in the use of condensate neutralizers, particularly in new construction. DOE evaluated the population weighting of States subject to the IPC or UPC and determined that approximately 73 percent of the U.S. population would be in States or jurisdictions that fall under the IPC or similar code requirements. DOE also reviewed available data on States that require ASME stamps and ASME-related inspections for water heating equipment and what thresholds are used but recognizes that such inspections are safety inspections of the equipment and would not generally address condensate disposal issues. Based on its analysis of the language of these requirements and discussions with others in the industry, DOE revised the estimate of equipment using condensate neutralizer upwards, using an average for new construction of 60 percent and separately 30 percent for replacement equipment in the LCC analysis. Both the assumed prevalence of condensate neutralization equipment and the expected cost of such equipment are discussed in chapter 8 of the final rule TSD.

PHCC stated its members are concerned with the need for condensate disposal with higher efficiency equipment, noting DOE reduced the instances where additional work would be required assuming that the International Plumbing Code requires a floor drain. PHCC disagrees, stating section 502 of the code does not require a drain; instead, it requires the relief valve to discharge to a suitable location such as a floor, water heater drain pan, waste receptor, or outdoors. In addition, it requires that relief valves, as emergency devices, are allowed to discharge to the floor and in most cases that is what they do. Service personnel are directed to solve the problem. Condensate however is an ongoing discharge, and a method of disposal is required per section 314.1 of the International Plumbing Code ("IPC"). Further they note that while in some instances existing installation floor drains may be present, additional piping may be required to get to the drain location, and if that presents a trip hazard, owners may elect to have a pump installed regardless. They comment that this situation will impact more than 10 percent of installations and likely more than 50 percent. PHCC also noted that in a new installation without new standards, consumers currently do not have to purchase condensing products. (PHCC, No. 28 at pp. 6–7) PHCC agrees that many new installations opt for high efficiency products already, but perhaps 25 percent to 30 percent would not. As such, some allowance should be included in new installations for additional condensate disposal expenses. (PHCC, No. 28 at pp. 6–7) Joint Gas Commenters noted many commercial buildings with non-condensing equipment were not designed with plumbing systems to dispose of condensate. (Joint Gas Commenters, No. 34 at p. 4)

DOE interprets the comment from Joint Gas Commenters regarding existing buildings not designed with plumbing systems to dispose of condensate to refer to both condensate neutralization, which DOE addressed previously, and condensate disposal which is discussed here. With regard to the point raised by PHCC, DOE reviewed the language in the IPC and agrees with PHCC that the code does not require a floor drain be present in spaces where a water heater exists and allows for other means of dealing with discharge. In locations where drainage from the T&P valve could cause damage, it requires a pan and some method of disposal (either to the exterior of the building, a sump, or a floor drain). In a situation where discharge would not cause damage, water release could be handled as a maintenance call as noted by PHCC. DOE examined the UPC requirements for floor drains as well and notes the UPC does not appear to require floor drains for water heater temperature and pressure discharge valves explicitly. The UPC does have requirements for floor drains in certain areas, including what would be most commercial restrooms (see definition, commercial kitchens, commercial laundry spaces, and boiler rooms). The International Mechanical Code, part of the ICC series of building codes also requires floor drains. DOE examined other codes adoptions that occur at the municipal or state level, and requirements for drains in non-boiler mechanical rooms seem to occur through amendments in certain codes. For example, the New York City code 501.16 seems to require drains at the base of all chimneys and gas vents.[75] In addition, DOE notes that mechanical rooms that must deal with condensate from air handlers will typically require some method of condensate disposal. However not all such rooms will also be used for water heaters. In rooms that have pumps, it appears that some form of drain will be common for convenience to deal with replacement or leakage. DOE believes that in many locations where commercial water heaters are installed, it appears that drainage in the form of floor drains, trench drains, etc., will be provided for or will be close by in existing buildings and expects this to be more common in the case of new construction, in part due to the prevalence of condensing equipment. However, DOE does agree that the ability to gravity drain condensate may be limited in existing construction and in the NOPR included the 10 percent factor. While DOE agrees with PHCC that there may be factors at work such as avoiding a tripping hazard, it is

[75] See www.nyc.gov/assets/buildings/apps/pdf_viewer/viewer.html?file=2022FGC_Chapter5_ChimneysVentsWB.pdf&section=conscode_2022, p. 7.

speculative to DOE how this leads to a fraction as high as 50 percent as stated by PHCC. PHCC is speculating that there in as many as half or more cases there may be a floor drain present that building owners would choose not to use and instead pump condensate to some other location. DOE believes this is a highly speculative statement that implies that even where a floor drain exists, in a majority of cases there is an alternative location in which to dispose of condensate and owners would choose to incur additional installation costs to reach that alternative drainage location. That said, because the tripping hazard is a possible concern not embodied in DOE's original 10 percent factor, DOE modified the LCC to increase the fraction of installations with condensate pumps to 15 percent.

For this final rule, DOE also conducted research on the appropriate condensate pump size and associated cost for each equipment category, which resulted in an update to the condensate pump assignment for residential-duty and commercial gas-fired storage water heaters. For the withdrawn May 2016 CWH ECS NOPR, DOE used one condensate pump for all equipment types while for the May 2022 CWH ECS NOPR and this final rule DOE used two sizes of condensate pumps to reflect difference in input rates between classes. Chapter 8 of the TSD contains more information on the methodology, raw costs, and sources for the installation cost for condensate removal.

c. Vent Replacement

In both the withdrawn May 2016 and the May 2022 CWH ECS NOPRs and in this final rule, DOE conducted its analysis under the assumption that condensing CWH equipment would commonly use the same, typically vertical, chase for the venting system as the non-condensing CWH equipment that it replaces. DOE recognizes that each venting situation may be unique and will depend on the location where the water heater is installed within the building, whether new construction or replacement, the height of the building and or distance to the outside wall. In new construction the latter two variables will in fact be influenced, in part, on the water heater and water heater efficiency levels selected. In an existing building that uses non-condensing water heaters, the most common path for exhaust is expected to be a vertical chase and flue or chimney, which formed the basis of DOE's analysis, although DOE recognizes that other existing building flue scenarios may exist including horizontal power venting of non-condensing equipment, vertical power venting of non-condensing equipment, and exterior. For this final rule, DOE maintained its venting methodology and associated venting costs for scenarios in which non-condensing CWH equipment is replaced by condensing CWH equipment.

DOE incorporated the sleeving of existing vent systems in its May 2022 CWH ECS NOPR analysis. For existing buildings with natural draft (Type B) venting systems that have no elbows and possess vent lengths less than or equal to 30 feet, DOE assigned sleeving of the existing vent with PVC venting to 50 percent of replacement scenarios. DOE's NOPR and final rule analysis provides for using an existing vent as a sleeve only for those installations meeting the criteria defined previously.

For this final rule DOE's analysis accounts for installation costs in the commercial and residential sectors for both replacement and new construction markets, along with an appropriate set of installation scenarios within each market and sector combination. Equipment installation and removal costs are separate from venting system installation and removal costs. The equipment installation labor hours for representative CWH models ranged from 4 to 22.4 hours, depending on the equipment category. The labor hours to remove CWH equipment in replacement situations were determined to be an additional 37.5 percent of the installation labor hours on average, meaning they ranged from an additional 1.5 to 8.4 hours depending on the equipment category. These labor hour calculations were based on a linear regression formula using data from the RSMeans Facilities Construction Cost Data, ENR Mechanical Cost book, and Whitestone Facility Maintenance and Repair Cost Reference. This formula escalated equipment installation labor hours based on the input capacity and/or volume of the CWH equipment, as expressed in the sources that DOE relied upon. DOE has found no information that suggests basic CWH equipment installation or removal cost varies based on thermal efficiency rather than input capacity and/or volume. DOE accepts the methodologies of its sources that the activities required to install minimum-efficiency and high-efficiency equipment are inherently similar. This approach to developing costs for CWH equipment installation or removal was not changed from the withdrawn May 2016 CWH ECS NOPR.

In addition to equipment installation and removal, DOE accounted for the labor hours to install and remove venting, scaled to the vent length in linear feet and/or the number of components (*e.g.*, elbows) in the venting system. These hours differed based on the vent material and vent size involved in the installation and were developed using data from RSMeans.[76] The labor rates in DOE's analysis depended on the crew type conducting the installation, region in which the installation occurred, and whether venting was installed in residential or commercial buildings. For the installation of Type-B venting for non-condensing CWH equipment, average labor rates (including overhead and profit) ranged from $65 per hour in the residential sector to $89 per hour in the commercial sector. [77] For the installation of PVC venting for condensing CWH equipment, average labor rates used by DOE (including overhead and profit) ranged from $66 per hour in the residential sector to $89 per hour in the commercial sector.[78] Regional adjustments to these labor rates called for multipliers ranging from 0.51 (Arkansas) to 1.64 (New York).[79] For this final rule, DOE did not further adjust labor rates for venting except to use the most up-to-date source data.

In addition to accounting for equipment installation and removal, and venting installation and removal, DOE also incorporated an appropriate set of installation cost additions and subtractions, which included labor and material, arising from unique circumstances in replacement scenarios. These installation costs included reusing existing vent systems (when replacing non-condensing CWH equipment with similar non-condensing CWH equipment), relining of chimneys, installing condensate drainage, and sleeving of existing vent systems with certain replacement venting systems, introduced in this final rule analysis. DOE did not incorporate the costs of sealing off chases and roof vents or moving mechanical rooms because it is logical that condensing

[76] RSMeans. Estimating Costs with RSMeans Data, CostWorks CD, Mechanical Costs 2022.
[77] RSMeans. Estimating Costs with *RSMeans Data, CostWorks CD, Mechanical Costs 2022*.
[78] *Id.*
[79] *Id.*

CWH equipment would reside in the same location and use the same chase as the non-condensing CWH equipment it replaced.

In response to the May 2022 CWH ECS NOPR, Joint Advocates suggested that DOE thoroughly analyzed the cost of installing new venting systems, and that the analysis is comprehensive and reasonable. (Joint Advocates, No. 29 at pp. 2–3)

The Joint Gas Commenters stated that EIA data show that "more than half of all commercial buildings were constructed before condensing commercial water heaters were introduced to the market" and stated that condensing products are incompatible with millions of these existing commercial buildings. They further added that the modifications required to alter these existing buildings to accommodate the use of condensing products are far more complicated, extensive, and burdensome than DOE's analysis assumes. (Joint Gas Commenters, No. 34 at p. 3)

DOE agrees that many commercial buildings were constructed before condensing water heaters were introduced to the market, but does not agree that millions of commercial buildings are thus by definition incompatible with condensing water heaters. This statement implies that such water heaters cannot be used in older buildings. Evidence strongly suggests otherwise. Since the mid-1990s, the condensing water heater market has grown rapidly. That growth has been substantially faster than the growth of commercial building stock. The implication is that condensing water heaters have been installed in preexisting commercial buildings, which supports the conclusion that older buildings are not incompatible with condensing water heater installations. DOE acknowledges and addressed that in many existing buildings the venting systems would need to be replaced and, as discussed in Appendix 8D, DOE included costs for items such as vent removal, whether a condensing vent can be sleeved into an existing non-condensing vent, and whether an existing chimney needs to be relined. The percentage of water heaters that potentially require vent modifications is identified in Table IV.29. DOE's analysis considers the cost of these building vent modifications, but the need to modify the building vent system does not make the building incompatible. However, this could mean that there are additional installation costs to be considered. DOE's analysis has accounted for the possibility that certain installations—including some, for example, in certain older commercial buildings—may incur exceptional costs. To the extent that unusually high costs may be incurred, DOE has included significant exceptional cost adders in 2 percent of buildings in its analysis of venting costs. This is discussed in section IV.F.2.d of this document and in TSD chapter 8.

The Joint Gas Commenters also noted that condensing water heaters are generally either power vent or direct vent products. They note that power vented water heaters are typically vented horizontally and require positive pressure venting—generally through a horizontal conduit, powered by a fan or other additional electronic device—to generate sufficient pressure and flow to vent the combustion gases. Further, they stated such installations require plumbing drains to dispose of the condensate developed in the operation of the appliance. They also stated that direct vent water heaters use special coaxial venting with separate chambers for intake and exhaust in a single vent pipe. Joint Gas Commenters stated that these are vented through the side wall and noted several additional factors about power vented equipment including the cost of interior renovations, the need to have electricity available to operate fans and condensate pumps, restrictions on sidewall venting in some urban areas, the need for on lower floors for terminations to be located 7 feet or more over public sidewalks or above the snow level, and other factors. (Joint Gas Commenters, No. 34 at pp. 4-5,7–9) Joint Gas Commenters further stated multi-story buildings in urban centers cannot use horizontal venting because it is impossible to install and service vent terminations. In addition, they stated that wall penetrations could compromise the structural integrity of buildings in many cases. (Joint Gas Commenters, No. 34 at p. 5) Bradford White noted limitations to vertical venting may exist as a water heater in a basement/ground floor mechanical room may not be certified with a long enough vent length to vent vertically through a building's roof. Additionally, it may not be able to vent horizontally due to jurisdictions prohibiting side wall venting in these applications. (Bradford White, No. 23 at p. 4)

DOE disagrees with the Joint Gas Commenters that direct vent water heaters necessarily use coaxial venting. This is an option for direct vent systems and will have some advantages in certain situations, though is not a necessary part of direct vent design as coaxial vent solutions are relatively new. Two pipe direct vent solutions, such as mentioned by PHCC, have been around longer. Further, coaxial venting is used for both horizontal and vertical vents based on manufacturers' literature.

Regarding the availability of electrical power, DOE believes that it is generally available in most commercial situations where a commercial water heater is situated, and provides for costs to bring electricity close to the water heater location in cases where it may not be nearby. A review of the market shows that non-condensing storage commercial water heaters commonly utilize technology including electronic ignition, electronic flue dampers, and commonly electronic controls. In addition, many are power vented. While the baseline efficiency model developed for this rulemaking were simplified in this respect, the actual market is quite varied. Further, even in equipment that does not use electric power, much of the equipment may be installed in spaces like mechanical rooms where electric power is readily available. For instances where this is not the case, DOE has provided for electric power to be included in the installation costs. DOE received no comment that the estimated cost to bring electric power in these instances was inadequate. As noted previously, DOE modified its assessment of the need for condensate pumps in the final rule analysis to reflect higher anticipated usage needs, particularly in existing buildings.

Regarding interior renovations, it is not clear what interior renovations may be envisioned outside of those associated with flue replacement costs. DOE agrees that in some dense urban areas there may be restrictions on how sidewall venting is achieved, including the appropriate considerations for sidewalks immediately adjacent to buildings, and more generally those vents need to exhaust above the snow level. However, these are requirements so that sidewall venting, when used, is implemented in a safe manner. Other safety requirements are that exhaust vents are not located near operable windows or air intakes and these latter requirements are also found when exhausts are used for non-condensing equipment. These restrictions also apply to sidewall venting of non-condensing equipment, but do not imply that non-condensing equipment cannot be used. DOE's analysis did not assume sidewall venting and DOE and other commenters (see *e.g.*, PHCC, No. 28 at p. 7) note sidewall venting may in fact be less expensive than vertical venting.

DOE is not clear what is being implied regarding structural integrity. DOE believes that the structural integrity of a building is an engineering consideration to ensure that the building is operable and structurally safe for its occupants. Competent contractor assistance may be required to select the appropriate areas of a wall to drill, to perform the drilling safely, and to ensure that the resulting vent does not allow water to enter the wall, but there is nothing in this process that inherently damages building integrity. Joint Gas Commenters have provided no evidence that the structural strength of building will be compromised by the addition of a horizontal exhaust vent.

PHCC stated that they took issue with the phrase that "Condensing CWH equipment is not required to sidewall vent exclusively and presents no special limitations restricting vertical vent scenarios," noting that all manufacturers have vent length limits, and that the "effective vent length" needs to consider fittings, usually elbows, and that in tall buildings, the vent length of the equipment can be exceeded and the installation cannot be made in that location, and perhaps this becomes an impossible location. (PHCC, No. 28 at p. 7) Joint Gas Commenters noted in discussing vertical venting, manufacturers place limits on the length of vertical vents. (Joint Gas Commenters, No. 34 at p. 12)

Regarding the PHCC comment about no special considerations for vertical venting, DOE's language did not mean to imply that vent length is not an issue; rather, that in the context of whether the vent is vertical or horizontal, the distance that a power vented condensing water heater can vent is generally the same as a non-condensing product. DOE notes that the distance a power vented product will vent is largely a function of fan size and vent diameter used. DOE understands that consideration of pipe elbows and bends must be considered due to pressure losses through these components but notes that the market is already moving to make longer vent length products more available in condensing equipment. Condensing commercial water heaters with maximum vent length of over 200 ft are available on the market today as standard products without significant increases in vent diameter for a given combustion air throughput. DOE also notes that natural draft vent tables in the National Fuel Gas Code only go to 100 ft vent height and that where the actual height of a vent exceeds these tables, recognized engineering methods must be used to establish vent capacities for such systems. DOE statements here do not imply that such very long natural draft vents do not exist, but that they are already in the realm of professionally engineered systems. DOE also notes that draft inducers for combustion equipment already exist on the market and that these might be used to address combustion air from condensing equipment in very long vent lengths.

PHCC commented that DOE asserts there would be sufficient space in an existing chase to install plastic vents and stated that it depends, and every installation is unique. Typically chase sizes are built to a minimum dimension to maximize building floor space. If the existing vent is large, the new vent may fit. PHCC stated that most high efficiency systems (particularly 95 percent or better) will use two pipes to achieve maximum efficiency. Depending on the vent length, whether upsizing is required, and if using two pipes, the existing chase may well be too small. PHCC added that in the real world this may not matter because there will be significant work to open the chase, install and support the piping, firestop the floor and ceiling penetrations, and close the chase such that making it somewhat larger will be trivial. PHCC questioned whether DOE accurately accounts for this additional work because the May 2022 CWH ECS NOPR suggests this will be an easy solution. When it is suggested that existing chases be used, PHCC assumed that existing venting materials would be removed, and the piping placed in the same vertical building compartment. The chases would need to be opened throughout the path of the vent, existing piping removed, new piping and supports installed and the chases closed up. Typically, chases are fire rated construction, and particular care must be used to ensure the integrity of these spaces. (PHCC, No. 28 at p. 8) Joint Gas Commenters asserted that based on interviews with installers, condensing water heaters are not installed using the existing chase. Impediments include that the venting for the new water heater cannot be suspended in a vertical chase; it requires support at frequent intervals and that requires sufficient space in the chase for vent hangers and often requires physical access to the chase for installation. (Joint Gas Commenters, No. 34 at p. 12)

PHCC noted that in the discussion of sleeving and using the same chase when changing vent systems, both of these options also present problems. Although the systems may tend to be of plastic material, those materials have weight that must be accounted for. Systems must be supported to hold the weight and prevent seismic movement, two issues that could cause failures in the vent system. Typical manufacturer instructions direct installers to support the pipe every 5 feet vertically and every 5 feet horizontally. It is unclear how this support spacing would be affected in a sleeved scenario. Some contractors have made efforts to install plastic vent piping in existing large masonry chimneys, and complicated hangar arrangements must be devised for this. Pipe joints must be made prior to placement in the chimney and the vent installed as a unit, which PHCC noted is cumbersome and costly. (PHCC, No. 28 at p. 7)

In response to PHCC concern regarding sufficient space in existing chases, DOE notes that in cases where an existing chase is used with Category I venting, the cross-sectional area of the existing Category I or Type B vents, designed as they are to vent flue gasses through natural draft, will generally be substantially larger than that required for venting condensing products. This is true for two main reasons. First, the flue path in a Category I vent operates only on the natural draft pressure. The flue path is therefore typically larger in diameter than that of a typical Category IV where combustion products are pushed through the vent with a fan. For example, per ANSI Z223.1-2015 (National Fuel Gas Code), when considering a vent stack height of 30 feet, a lateral distance of 10 feet, and a 199,000 Btu/h input rate requires a 6-inch inside diameter vent flue path. A strictly vertical vent with no lateral flow in the system could use a 5-inch vent. By contrast, a similar input rated condensing water heater venting over the same distances would commonly be vented with a 3-inch flue diameter vent. When considering longer vent height (50 feet), a 5-inch Category I vent could be used with up to 5-foot lateral distance, but otherwise a 6-inch Type B vent would be required. However, for the Category IV, condensing water heater of the same input a 4-inch vent pipe could be used. Characteristically, the vent pipe diameter for a condensing water heater will typically be smaller, sometimes considerably smaller, than for a natural draft water heater. Therefore, DOE does not believe this issue is as significant as PHCC states.

In addition, because it is venting higher temperature flue gases, the Type B vent must have at minimum an additional clearance of at least 1 inch from any combustibles in the flue path. Because of the need for larger diameter vent pipe and the additional need for clearance, the cross-sectional area that would be required for a single flue chase for a Category I vent is typically much larger than for the exhaust vent for the same input rating for a Category IV vent such as would be used for a condensing water heater product. In addition, because of the higher efficiency for the condensing product and the greater hot water output for a given input rating, it may be possible to downsize the water heater input rating with possible further reductions in vent size in some situations.

DOE acknowledges that in the case where direct vent products (using a separate inlet and exhaust pipe or two-pipe as referred to by PHCC) are selected for the condensing equipment, adding a direct vent inlet pipe to an existing chase may not always be possible. A direct vent is generally a separate optional feature that becomes prevalent with the use of non-natural draft water heaters, but not a requirement in such an equipment replacement. Inspection of CWH product literature shows most condensing equipment allows for direct vent as an alternative to the standard "power exhaust" vent configuration. Both direct vent and standard, "power exhaust" water heater designs require ventilation air for proper and safe operation. In a replacement situation, the space where a similar sized Category I water heater is already located should have this sufficient air supply for safe operation. A direct vent water heater allows the intake air to be taken from another location, typically outside of the building envelope. Where a direct piped vent is used to bring air in from outside, it will typically reduce overall building infiltration and provide for additional efficiency benefits to the building not accounted for in DOE's analysis, providing for an overall building efficiency improvement. A direct vent configuration is not a requirement for a 95 percent thermal efficiency rating per the DOE test procedure. Further, even where used, the inlet air may not have to follow the same path as the exhaust flue. In some cases, a coaxial-two pipe vent may also be an option with an overall pipe diameter not significantly different from the original Type B vent and without the additional clearance-to-combustibles requirement. The Joint Gas Commenters state that a direct vent water heater uses special coaxial venting that has separate chambers for intake air and exhaust in a single assembled vent piece. (Joint Gas Commenters, No. 34 at p. 4) DOE disagrees with the implication by the Joint Gas Comments that a direct vent implies or necessarily (or even commonly) requires use of a coaxial vent in most applications. DOE acknowledges that in some cases coaxial vent systems can be an option during installation of condensing equipment and may reduce installation costs or provides other benefit, but they are not required in all applications.

With regards to supporting vents installed vertically, multiple options may be available. Where PVC plastic vents pipes are used, they are solvent glued together forming a permanent bond where the PVC at the bond becomes continuous and joints are of similar strength as the pipe itself, which allows for longer sections of vent piping without supports. This is unlike Type B vent sections that lock together upon twisting and must be supported section by section. Horizontal PVC flue sections can be supported similar to water piping, where the pipe supports are installed periodically along the flue length as noted by PHCC; however, the weight of PVC/CPVC is much less as a flue than as a water pipe and piping supports can be of lighter construction. However, it is important in a condensing product application that flues are sloped properly for condensate drainage, and horizontal flues need to have enough supports to prevent sagging. Vertical flue sections will also require support, but unlike Type B vents that may require support at each section, the continuous nature of the joined PVC pipe can allow longer spans of vertical flue sections where required as long as the weight is adequately supported.

Further, when polypropylene vent connections are considered, these are typically much lighter (manufacturer literature notes up to one third of the weight of PVC). The individual polypropylene vent sections are clamp connected. Not only can rigid polypropylene vents be supported using greater spacing between supports, flexible polypropylene vent products are available that can be readily used to allow for the lining of a chimney, Type B vents, and other existing chases, and that is supported primarily from the top where simple spacers may be used to provide some lateral centering. Note that thermal expansion in length may need to be accommodated for with PVC/CPVC flue systems; however, based on manufacturer literature, the expansion of ridged polypropylene vent systems is accommodated for at the joints between pipe sections.

Regarding support in a sleeved vent, DOE’s analysis uses only a restricted set of sleeved vent scenarios as outlined previously. Further, while cognizant that using straight PVC pipe may be cumbersome for the reasons indicated by PHCC, DOE recognizes that with different venting systems, particularly polypropylene or stainless flexible venting, additional sleeving options are possible. DOE notes that manufacturers of polypropylene vent products make components that are designed specifically to allow the use of sleeving in existing Type B vents. Regardless DOE's NOPR and final rule analysis provides for using an existing vent as a sleeve only for those installations meeting the criteria defined previously and does not believe that it has overstated the possible use of this technique.

In response to DOE's discussion of the selection of vertical venting in the May 2022 NOPR analysis, PHCC agreed that there may be sidewall venting issues for some buildings but noted that should sidewall venting be possible; in some cases, it could be more cost effective than vertical venting. (PHCC, No. 28 at p. 7).

Atmos Energy stated that DOE should collect actual product and installation costs rather than relying on assumptions and inadequate data. (Atmos Energy, No. 36 at pp. 2, 4)

DOE does not agree with Atmos Energy that the collection of contracted or retail costs for equipment today provides a more accurate representation of future equipment costs under a standards scenario than what can be provided for in DOE's engineering and markup analyses. In DOE's experience reviewing such information, cost estimates provided by contractors vary widely in terms of information provided, from a total single price inclusive of everything including the equipment, to considerably detailed estimates. Even if detailed installation costs from a large enough statistically valid sample were made available from individual contactors, collecting and using such information would be highly impractical and could potentially require making as many or more assumptions as DOE' current analysis to which Atmos Energy is objecting. As to the installation costs, particularly in replacement situations, DOE's is not aware of an extensive source of national data on new or replacement installation of higher efficiency, condensing, CWH equipment installation. DOE has estimated costs considering publicly available sources, considered variation in vent length and diameter in its venting model and provided for variation in venting and material and labor costs using a national construction data source. DOE agrees with PHCC that in many cases horizontal venting may often be less expensive than a vertical vent solution. A good example of this is where the mechanical room, commercial kitchen, or other space where a water heater is located has an exterior wall on one or more sides. DOE believes this is a common, but not ubiquitous, occurrence. Because of the complexity of many larger commercial buildings, the location of the water heater within the building is not always assured, but when replacing a Category I type water heater, there will generally be a vertical vent path.

d. Extraordinary Venting Cost Adder

In response to the withdrawn May 2016 CWH ECS NOPR, some stakeholders argued that some venting installations can be physically impossible and/or prohibitively expensive to install condensing vents. In the May 2022 CWH ECS NOPR, DOE acknowledged the possibility that its analysis of installation costs may not capture outlier installation scenarios that involve uncommon building conditions that may further reduce or increase installation costs. DOE expects that these situations would be small in number and that it has captured an appropriate set of installation scenarios that are typical of residential and commercial buildings. For the May 2022 CWH ECS NOPR and this final rule, DOE researched the question of the prevalence and cost of extraordinarily costly installations. The one source identified that could be used to quantify extraordinary vent costs was the report submitted by NEEA in DOE Docket EERE-2018-BT-STD-0018.[80] Using this as a reference, DOE implemented an extraordinary venting cost adder, which was included in the May 2022 CWH ECS NOPR LCC model as a feature of the main case. DOE used data from the NEEA report for both the May 2022 CWH ECS NOPR and this final rule to capture extraordinary venting costs.

In the NEEA report it was stated that due to vent configurations, between 1 and 2 percent of replacements might experience extraordinary costs between 100 and 200 percent above the average installation cost. Because there is no clear linkage between specific situations and extraordinary costs, DOE implemented this by adding for each equipment category two additional variables. One is a probability of occurrence and the second is the multiplier. For 2 percent of cases, DOE assumes a multiplier between 200 percent and 300 percent. In all cases, the LCC model estimates the total installation cost, and multiplies it by the multiplier. In 98 percent of cases, the multiplier is equal to 1.00, or 100 percent. When the LCC model selects the extraordinary installation cost case, it also selects a multiplier between 200 and 300 percent to multiply the estimated installation cost. In the May 2022 CWH ECS NOPR, DOE asked for comments on this adder.

[80] NEEA, Northeast Energy Efficiency Partnerships, Pacific Gas & Electric, and National Grid. Joint comment response to the Notice of Petition for Rulemaking; request for comment (report attached – Memo: Investigation of Installation Barriers and Costs for Condensing Gas Appliances). Docket EERE-2018-BT-STD-0018, document number 62. *www.regulations.gov/comment/EERE-2018-BT-STD-0018-0062*. Last accessed July 8, 2021.

AHRI estimated that a small business or property owner could have $1k to $10k in additional installation costs to convert from a non-condensing unit to a condensing unit. AHRI noted that several factors (including region, size of load, municipal restrictions, historic building designation/protections, available materials and labor costs) can all factor into affixing a level of extraordinary venting costs. Rheem agreed with the AHRI comments. (AHRI, No. 31 at p. 4; Rheem, No.24 at p. 5) A.O. Smith made a similar comment noting that venting costs in retrofit or replacement cases might be significant or cost-prohibitive due to a combination of tight mechanical rooms, insufficient clearance between buildings for sidewall venting, and common venting. A.O. Smith does not have an estimate of the number of installations that may face extraordinary installation costs but recommends that DOE evaluate the number and type of buildings in metropolitan areas. As an example of extraordinary installation costs, A.O. Smith estimated that installing stainless steel venting materials in a typical NYC 5-story building for a commercial water heater or boiler in the basement could cost $32,500. (A.O. Smith, No. 22 at pp. 6–7) In reviewing the A.O. Smith comment, DOE is unclear which product classes or vent sizes were being considered in their estimation because the comment did not specify labor beyond an estimate of 1.5 times material costs, and presumed material costs of $200/lineal foot, which are higher than the costs identified by DOE for stainless AL29/4C vent in diameters needed for the representative condensing equipment sizes analyzed. With respect to AHRI's and A.O. Smith's list of factors, DOE agrees with these as potential issues that may impact real world costs.

AHRI also pointed to the venting analysis used in commercial packaged boilers that appears to be more exacting, and AHRI stated it provides a better representation and encouraged its use in the CWH analysis. (AHRI, No. 31 at p. 4) APGA noted that it appears that DOE is treating venting in commercial water heaters differently than for other gas fired appliances. (APGA, Public Meeting Transcript, No. 13 at p. 57) Joint Gas Commenters criticize the use of one representative model which results in one vent size and contrasted this to the 2016 Commercial Packaged Boiler (CPB) TSD that provided an equation for the relationship between product input rate and vent diameter. (Joint Gas Commenters, No. 34 at p. 18)

The venting logic used in DOE's boiler analysis was essentially the same as used in the CWH analysis. The general methodology and assumptions for determining the size and type of venting material based on input rate was essentially the same as well as the decision methodology for when a vent could be reused or would need to be replaced. A difference in approach was largely the result of the CWH engineering analysis approach which looked at one representative unit size for each category of equipment analyzed whereas, in the CPB engineering analysis approach, two size classes (commercial packaged boiler with rated input between ≥300,000 and ≤2,500,000 Btu/h and commercial packaged boilers with rated input >2,500,000 Btu/h) were already defined as DOE classes for each output type of CPB equipment (i.e. hot water or steam) and for each fuel (*i.e.*, gas or oil) and one representative equipment size was selected to be representative of each size class in that engineering analysis. Because of the way cost data was collected for the CPB engineering analysis, curves representing the cost variation by size within the equipment classes were developed and it was possible to use these data, along with additional data on sizing equipment to peak building loads for the CBECS and RECS buildings and assumptions on the typical number of boilers in buildings by peak building load, to provide greater variability in boiler sizes analyzed in the CPB LCC. The lack of data on variation in cost with equipment size from the CWH engineering analysis, the greater complexity in sizing to building water heater loads, and the lack of data on characterizing the number of water heaters within a size class that would be installed in buildings made such an approach practically impossible for the CWH LCC model. Further, while there is variation in equipment size in water heaters, DOE believes that the variation in size for the CPB is significantly greater than for the CWH equipment in this rule, at least for the vast majority of shipments. DOE does recognize that for all but residential duty water heaters, larger equipment than represented in the engineering analysis are sold into the market, but DOE believes its equipment selections are representative of the majority of units shipped. See section IV.C.3 for further discussion about DOE's decision to use representative equipment sizes in this analysis.

Joint Gas Commenters and Bradford White criticized the use of the NEEA report on extreme installation costs. Bradford White was concerned that the report was based on interviewing 15 different parties in 10 states, which they believe is too small of a sample size. Bradford White continued to add that all but one of the states are not a fair representation of where extraordinary venting cost adders will occur. These cost adders are likely to occur in larger, older cities (*e.g.,* Chicago, New York, Philadelphia). Bradford White recommends that a larger sample size is taken to understand these venting installation costs. (Bradford White, No. 23 at p. 4) The Joint Gas Commenters stated that DOE's economic analysis underestimated the costs imposed by condensing-only standards and suggested that the problems associated with condensing standards are common rather than uncommon scenarios. Joint Gas Commenters noted that DOE was basing the adder on one of the four identified categories of venting issues. Joint Gas Commenters further stated that through their own interviews of individuals with substantial experience replacing CWH equipment, they determined that DOE underestimates the percentage of difficult installations and the cost of such installations. (Joint Gas Commenters, No. 34 at pp. 12–14) Joint Gas Commenters point also to the distribution DOE applied to the extraordinary vent cost adder, calling it arbitrary, and stating that a lognormal distribution changes small net LCC savings to small net LCC costs, and the Joint Gas Commenters use this as evidence to support their position that DOE should collect data through field work. (Joint Gas Commenters, No. 34 at pp. 19–22).

In response, DOE notes that DOE researched the issue of extraordinary vent installation costs for CWH and was only able to identify the NEEA survey. Neither Bradford White nor the Joint Gas Commenters provided any data to support their comments, nor did they point to any alternative data or studies for DOE to examine for the purposes of reviewing extraordinary venting costs. Regarding the Joint Gas Commenters comment on the choice of a uniform distribution in DOE's analysis, DOE notes that the data that it used from the NEEA survey specifically defined the range of extraordinary costs as adding 100 percent to 200 percent to the typical cost and, lacking further details, DOE used a uniform distribution in this range. While DOE recognizes that a different distribution and range could exist, DOE received no data to characterize this from stakeholders. Specifically, with respect to the Joint Gas Commenters comment about using a lognormal rather than a normal (or uniform) distribution DOE notes that the data received from NEEA was cost adjustment data stated as a range, and DOE implemented the adder in such a way as to make use of this range in a manner that seemed most consistent with what was presented by NEEA. DOE notes that Joint Gas Commenters provided their example of the lognormal distribution as illustrative of what a lognormal distribution could look like but did not link this back to actual data, nor did they say their presented distribution was in fact the correct distribution for use in this analysis. For these reasons, DOE maintained the use of a uniform distribution for the final rule.

WM Technologies and Patterson-Kelley stated they understand that the CWH analysis uses a low probability multiplier that models difficult venting considerations and would prefer DOE make a more exacting representation of this detail. They maintained that local requirements will prohibit some locations from installing condensing gas fired products based on building structure, orientation, or location and that this percentage will vary significantly across the nation, noting that 1940s multifamily units in certain densely populated regions (*e.g.*, New York, Chicago and Boston) would find all condensing efficiency regulation cost prohibitive. WM Technologies noted that this is why the Northeast continues to have a majority of atmospherically vented products while the West Coast typically has a higher rate of adapting to condensing products. (WM Technologies, No. 25 at p. 7; Patterson-Kelley, No. 26 at p. 5) Patterson-Kelley believes the percentage of the population incurring excessive costs when replacing a non-condensing appliance with a condensing product is more than five percent. (Patterson-Kelley, No. 26 at p. 5)

PHCC had concerns related to installations with venting installation issues and noted the recognition of this by DOE in the May 2022 CWH ECS NOPR. Although PHCC cannot provide lists of locations where these issues may occur, PHCC disagreed with DOE, stating that more than 1 percent to 2 percent of installations will be affected. PHCC asserts that problem installations would likely be tall buildings, perhaps 10 stories or more, in metropolitan areas. PHCC stated that the extraordinary cost adder lacks a foundational basis, that it is unclear how the adjustment is applied, and that in many cases it is understated. PHCC maintains that there are significant venting issues awaiting the implementation of this rule. (PHCC, No. 28 at pp. 7–8)

Conversely, NEEA supports DOE's conclusions on flue gas venting and its analysis method thereof, which aligns with the findings of independent research previously submitted to DOE. NEEA stated that condensing gas-fired water heaters can be installed in all commercial building applications and said that DOE's analysis appropriately accounts for the rare cases in which the solution bears increased cost. (NEEA, No. 35 at p. 1) DOE acknowledges NEEA's input.

For the final rule, DOE has considered both the data provided from NEEA and the comments received from the various stakeholders regarding the fraction of consumers who would be characterized in the extraordinary venting cost grouping. Numerous stakeholders suggested that 2 percent was not representative. As noted by Joint Gas Commenters, DOE based the 2 percent adder on the frequency of vent installation issues noted in the NEEA report. DOE acknowledges that there were other potential installation cost issues noted by NEEA, and the high level summary statement was that fewer than 5 percent of installations were encumbered by any of the significant installation challenges identified. The other challenges noted by NEEA were, however, less costly than the 100 to 200 percent cost adder, and/or were already being addressed in the LCC model estimation of installation costs (masonry chimneys). While recognizing the range of comment on this issue, DOE believes that the data provided by NEEA through the survey of contractors provides an appropriate estimate for the fraction of the installations that might be considered to have extraordinary costs, and has continued to include this figure in its final rule analysis, along with the range of extraordinary cost multipliers established in the NEEA survey.

e. Common Venting

Certain CWH equipment installations can feasibly be commonly vented in certain building applications, where multiple individual equipment units are connected to a single, non-pressurized, combustion air vent, suitable for use with Category I equipment. However, as described more in the ensuing paragraphs, in these instances, DOE believes that CWH equipment typically is not commonly vented with other, disparate gas-fired equipment (like furnaces). Commonly venting disparate gas-fired equipment with significantly different capacities (such as a water heater and a boiler in a building) complicates the design and sizing of the common vent, since it needs to accommodate exhaust of a wide range of flue gas volume due to the different operating profiles and flue capacities required for disparate equipment as well as the seasonal variation of load. However, DOE understands that multiple, similar units of CWH equipment may be more frequently commonly vented together since the CWH equipment typically operates in unison, calling for a specific vent size. When multiple units of CWH equipment are commonly vented, building engineers design the common-vent system to suit a total input rating of all gas-fired equipment collectively as well as the input ratings of individual units. In the May 2022 CWH ECS NOPR, DOE stated its understanding that the installation of these units typically occurs all at one time. As a result, each unit should have the similar expected lifetime and replacement cycle. Therefore, when one unit fails and requires replacement, the other units sharing the common vent should also be nearing the end of their lifetimes. Thus, the stranded cost of any naturally-drafted, non-condensing CWH equipment due to amended standards would have limited residual value, which may have been relinquished regardless of amended standards if a consumer opts to replace the older, but still functioning unit at the same time. As discussed more in this section, based on stakeholder feedback, DOE performed a sensitivity analysis regarding these assumptions and determined residual values from replaced equipment, which DOE has incorporated into its LCC analysis.

AHRI disagreed with DOE's characterization of their statement related to the withdrawn 2016 CWH ECS NOPR relating to customers handling common-vented equipment by replacing all equipment at the same time. (AHRI, No. 31 at p. 1) PHCC commented that it believes DOE misinterpreted other stakeholder statements regarding replacement of individual devices in common venting situation. (PHCC, No. 28 at pp. 8–9) While DOE captured the AHRI comment as stated in the withdrawn 2016 CWH ECS NOPR public meeting, AHRI clarifies that what they intended to illustrate was a misalignment of timing leading to the premature retirement of functioning equipment. While DOE did not receive data on the frequency of common venting of equipment, for the final rule DOE examined through sensitivity analysis a potential cost impact on the

LCC that could occur due to premature replacement of equipment, as discussed later in this section.

Joint Gas Commenters assert that common venting of CWH equipment and space heating equipment was common practice for over 100 years, and is still very common. Joint Gas Commenters stated that non-condensing appliances have the ability to share a common vent with other non-condensing appliances, and removing one or more units would disrupt the venting system of the other locations. (Joint Gas Commenters, No. 34 at pp. 4–5, 12–13) WM Technologies and Patterson-Kelley expressed concern with the prevalence of common venting disparate gas-fired equipment, stating it is so common that both the International Fuel Gas Code and National Fuel Gas Code have appendices devoted to the sizing of such venting systems. (WM Technologies, No. 25 at p. 5; Patterson-Kelley, No. 26 at pp. 1–2)

In response to the comments on common venting disparate equipment, DOE notes that for the 2016 commercial packaged boiler rule, DOE asked for input on common venting of disparate gas heating equipment. Comments on the frequency of common venting were inconsistent; however, in response to the commercial packaged boiler NOPR, AHRI stated that they believed that common venting of commercial boilers and commercial water heaters may in fact be relatively rare given the size mismatch between commercial boilers and commercial water heaters, such that common venting would be more than problematic because the common vent size would be so large that when the boiler wasn't firing there would be venting problems on the water heater. (*See* EERE-2013-BT-STD-0030; 81 FR 15870)

Based on this input from AHRI, DOE determined that common venting with water heaters would be negligible for large CPB equipment and would be uncommon for small CPB equipment. *See* 85 FR 1630. Based on this input DOE believes that to the extent common venting exists in a commercial setting it is most likely to be multiple water heaters as opposed to a water heater and another type of equipment.

With respect to the comment about the International Fuel Gas Code and National Fuel Gas Code, the codes provide for installations in residential setting as well as in commercial settings. In a residence, typically there are 2 major gas-fired appliances to be vented, a space heating appliance, *e.g.*, furnace or boiler, and a water heater. Thus, common venting when it does occur almost always is indicative of disparate gas-fired equipment. In addition, this equipment will typically be of sufficiently similar input rates to be common vented even where their usage profiles may be disparate. This is a situation which would not necessarily be the case in many commercial settings where there may be greater variation in the input ratings of the equipment serving the space heating and water heating needs of the building as well as more commonly the use of multiple individual equipment to satisfy either the space heat or the water heating needs. Thus, while these fuel gas safety codes provide for requirements for when common venting of disparate equipment is used, these codes do not tell anything about the frequency of these types of common venting applications, particularly in commercial settings. DOE also notes that while most residential gas-fired heating equipment is installed indoors, a substantial fraction of the commercial floorspace is heated using packaged rooftop equipment, a fact that further reduces the possibility of venting of disparate equipment.

Joint Gas Commenters state DOE does not include costs for redesign necessary to address common venting. (Joint Gas Commenters, No. 34 at p. 18) However, Joint Gas Commenters provided no evidence of what such redesign might cost. Because consumers have multiple paths they could take to deal with upgrading common-vented equipment, without detailed knowledge of individual installations it would be extremely difficult to estimate the incremental cost of redesign of replacements of individual components of the common-vented system. DOE did not receive input on the frequency of common vented systems. Further, DOE did not receive input on the frequency with which redesign of a common-vented system would be significant and not already a part of the expected installation cost. DOE notes that when considering the consumers incurring extraordinary vent costs, the cost of redesign is part of what results in extraordinary costs, and as such it is subsumed in the doubling or tripling of the venting costs for such installations.

AHRI, Bradford White and Joint Gas Commenters stated that DOE recognizes that product lifetimes vary and used a probability distribution to describe lifetime here and in other DOE rulemakings. They noted that modeling common vented equipment as if it is all replaced at the same time can lead to consumers forgoing useful equipment lifetime and modeling it if the other equipment is retained can lead to increased venting cost as consumers have to vent condensing and orphaned non-condensing equipment separately. (AHRI, No. 31 at p. 2; Bradford White, No. 23 at p. 3; Joint Gas Commenters, No. 34 at p. 13) Joint Gas Commenters add that one reason for having multiple units is to have a primary and a backup so there will be no loss of service when a water heater needs to be replaced, and that purpose would be defeated if both units are replaced at the same time (Joint Gas Commenters, No. 34 at p. 13)

Bradford White, WM Technologies, Patterson-Kelley, and Joint Gas Commenters noted that DOE assumes that all commonly vented appliances will be replaced at the same time if only one water heater fails and found the approach to product lifetime for common vented equipment concerning as DOE recognizes that products lifetimes vary and uses a probability distribution in numerous other standards' rulemaking as in the CWH LCC workbook. (Bradford White, No. 23 at p. 3; WM Technologies, No. 25 at p. 5; Patterson-Kelley, No. 26 at pp. 1–2) PHCC and Bradford White noted that while it is possible that multiple units that are commonly vented are replaced at the same time, they rarely see this occur, nor do they commonly see proactive replacement. As referenced previously, equipment lifetimes will vary unit to unit, even of the same model. If one unit happens to fail earlier in its life (*e.g.*, in year 3), it is highly unlikely that a building owner would replace multiple other units at the same time. (Bradford White, No. 23 at p. 4; PHCC, No. 28 at pp. 8–9)

WM Technologies and Patterson-Kelley both state that stranded water heaters are a fact in the industry and the impact on such installations should be taken into account in the LCC analysis. (WM Technologies, No. 25 at p. 5; Patterson-Kelley, No. 26 at p. 2)

In response to the comments, DOE elected to perform a sensitivity analysis related to common venting. To the extent that the loss of value of a second water heater on a common vent takes place, the cost is an up-front cost and can be treated as such. To analyze the issue DOE used the lifetime distributions by equipment class referenced in several comments to model what happens when you have two independent pieces of equipment operating at the same time. DOE modeled multiple permutations to address two key questions: (1) What happens if they are installed at the same time?; and (2) Is the answer different after one equipment lifetime than it is after multiple (*e.g.*, 3) equipment lifetimes? With respect to the second question, certain issues make the answer less than useful, namely, equipment today is different than it was 20 or more years ago and venting systems may have changed. While Joint Gas Commenters may be correct that equipment has been commonly vented for 100 years, consumers likely cannot vent today's hot water supply boilers with a boiler from 50 years ago because of changes in the technology. The result of this modeling showed that on average in commercial gas storage equipment a second water heater on a common vent would lose approximately 3 years of useful life; a second hot water supply boiler about 4 years; and residential duty gas-fired storage about 3 years. DOE did not analyze tankless units because they represent a newer technology and most of the equipment available today is forced air combustion and not suitable for venting with category I equipment. See chapter 3 of the final rule TSD for discussion of forced combustion in tankless CWH equipment.

Next DOE translated lost equipment life into an estimate of monetary value. Commenters have not provided data on the frequency of common venting, other than that it exists. For its sensitivity analysis, DOE modeled a scenario of 20% of non-condensing replacement water heaters might be common vented for each of the above categories where common venting was considered. The average value of the lost life of the second water heater assumed to be common vented was taken as a loss against the average equipment class LCC savings as calculated in this final rule for the pair of new water heaters that were installed in their place in the common venting replacement scenario. Based on this sensitivity analysis, DOE determined that the overall impact of the residual values was approximately $39 for commercial gas-fired storage; $22 for residential duty gas-fired storage; and $5 for instantaneous water heaters and hot water supply boilers. The LCC savings as calculated for the final rule could potentially be lowered via account for an analysis of this nature. However, the lack of information on the fraction of installations in which common venting has been utilized and the complexity of dealing with these historical installations and how remaining life may be correlated between CWH units are issues that did not support its incorporation in the base analysis. DOE presents it as illustrative of the fact that including this would reduce but not eliminate the economic benefits of the rule to consumers. DOE's sensitivity case is discussed in TSD chapter 8.

Bradford White disagreed with DOE's assertion that water heaters will be able to vent vertically in the case of common venting with other Category I water heaters as it will not be able to use the existing chimney as a chase as combustion products from existing water heaters will compromise non-metallic venting used by the new water heater. They further seek clarification on how polypropylene common vent kits can be used to vent both non-condensing, existing water heaters with a newly installed condensing water heater. They also commented that regarding horizontal vent replacement, that DOE noted "to the extent that horizontal natural draft venting is used at a job site, it is indicative that horizontal venting is allowed by the jurisdiction." and acknowledged that while that may be true, [and that there are] power venter kits that are used to horizontally vent natural draft water heaters, it is our experience that this is rarely done in the field. Therefore, this cannot be used as a good indicator of what local jurisdictions' codes permit. (Bradford White, No. 23 at p. 4)

DOE believes Bradford White has misunderstood DOE's point. DOE meant with the discussion in the May 2022 CWH ECS NOPR that there may be other options to both water heaters using the vertical chase when replacing the water heaters on the common vent. To the extent that a separate flue path may exist such as a horizontal venting from a mechanical room with an exterior wall, installers could very likely choose a simple horizontal vent option for the replacement water heater, and leave a functional non-condensing water heater in place, taking into account the relative size of the remaining Category I vent and the remaining water heater(s) input rate. Another option which may be present is the use of specified common venting procedures using multiple condensing water heaters (in a case where all units are replaced). In addition, DOE is aware of the Duravent FNS 80/90 vent solution, which allows for the use of an existing category I flue in conjunction with a condensing flue system which may be used in certain applications where replacement of the non-condensing water heater would be far out in time. However, in the case where an alternate path does not exist, DOE notes that multiple water heaters may have to be replaced.

f. Vent Sizing/Material Cost

Bradford White stated DOE's analysis of installation costs does not appropriately account for state level restrictions on the application of PVC venting. In New Hampshire, PVC venting is not permitted for exhausting combustion gases. In Massachusetts, only CPVC, polypropylene, and other piping approved by the Plumbing Board are acceptable. These codes do not disallow PVC based on size, as other commenters stated. (Bradford White, No. 23 at p. 3) Bradford White also asked DOE to elaborate on why they believe polypropylene venting will become a more viable, cost-competitive alternative by 2026. (Bradford White, No. 23 at p. 4)

After reviewing the comments from Bradford White and the requirements with regard to venting materials in New Hampshire and Massachusetts, DOE determined that in the case of New Hampshire, NFPA 54 was amended to require that a venting material would only be allowed to be used if the maximum set point temperature of the water heater does not exceed the safe operating temperature of the venting material selected. In the case of PVC vent material, the maximum storage temperature for use with PVC venting would be around 149 °F (based on the use of listed PVC vent products available that are rated to UL 1738). DOE agrees that this effectively does not allow PVC venting for the vast majority of products regulated under this rule. DOE also reviewed the requirements surrounding plastic venting materials for Massachusetts. Massachusetts requires that all venting products must be approved by the Plumbing Board. After consultation with a manufacturer of venting materials and review of the Massachusetts Consumer Affairs and Business Regulation website,[81] DOE confirmed that at least one manufacturers' product line of PVC vent piping that is currently listed to UL 1738 is allowed as a venting material according to the Massachusetts Plumbing Board. Based on this review, and the relative population of New Hampshire to the US total, DOE determined that the effect of restrictions imposed on PVC venting in New Hampshire would be de minimis for DOE's venting cost analysis.

[81] Accepted Plumbing Products Online System of the Massachusetts Board of Registration of Plumbers and Gas Fitters. *licensing.reg.state.ma.us/public/pl_products/pb_pre_form.asp* (Last accessed Dec 20, 2022)

With response to possible growth in the use of polypropylene vent materials, DOE does not have data on the relative use of different plastic venting materials and historic changes over time. DOE's intent in the May 2022 CWH ECS NOPR was only to note polypropylene venting as a relatively new option compared to other venting materials on the U.S. market that appears to have growth potential. Importantly, DOE did not modify its analysis for the May 2022 CWH ECS NOPR or this final rule to explicitly include polypropylene venting.

g. Masonry Chimney/Chimney Relining

In the May 2022 CWH ECS NOPR, DOE assumed that 25 percent of pre-1980 buildings have masonry chimneys and that 25 percent need relining. DOE also used these assumptions in the withdrawn May 2016 CWH ECS NOPR and asked for input. DOE did not receive further information or data on the percentage of buildings built prior to 1980 with a masonry chimney or the percentage of those chimneys that require relining in response. For this final rule DOE maintained these same assumptions to characterize masonry chimneys; which DOE used in the logic underlying the calculation of venting costs.

PHCC noted that with regard to the fraction of existing buildings with masonry chimneys, it cannot provide data, but suggests that the Department may want to break its pre-1980 assumption down into more discrete year bins and also encouraged DOE to review possible data from the General Services Administration ("GSA"), the largest occupier of offices in the country. It encouraged DOE to make further examination of available information and to refrain from making random assumptions regarding building stock. (PHCC, No. 28 at p. 8)

DOE appreciates PHCC's input on this topic. DOE reviewed GSA data and found it did not include information that provided insight into the fraction of existing buildings with masonry chimney venting or to develop more detailed estimates of this variable by finer year bins. Consequently, DOE did not update its methodology in this area for the final rule.

h. Downtime During Replacement

Joint Gas Commenters state that many CWH replacements occur on an emergency basis or "on an unplanned basis." For this reason, Joint Gas Commenters criticize DOE's statement that some businesses are able to plan ahead for CWH replacements. They further state that DOE failed to take into account additional down-time required for condensing CWH installations in buildings previously served by non-condensing equipment and the potential for lost business during the downtime. (Joint Gas Commenters, No. 12 at p. 14) Similarly, Joint Gas Commenters pointed out that DOE did not take into account lost business operations during replacement of heat exchangers. (Joint Gas Commenters, No. 34 at p. 19) DOE has no mechanism for determining what if any impact there would be on a consumer's business. As noted above, consumers have several avenues to avoid downtime, whether due to a replacement or due to a repair. DOE agrees with Joint Gas Commenters that a water heater failure can happen at any time. However, DOE assumes that many consumers would have contingency plans to cope with such emergencies and limit business losses, including potentially having insurance policies which include coverage of business loss due equipment failures or similar business impacting events. Because avenues exist for consumers to minimize or eliminate lost business, DOE continues to assume there is no need to add in costs for lost business.

DOE acknowledges that currently a wide range of industries are experiencing supply chain bottlenecks, and that could, in today's climate, add to the time required to replace water heaters. The standard established by this final rule however would not take effect for three years and DOE believes that these supply chain bottlenecks should be resolved by that time.

3. Annual Energy Consumption

For each sampled building, DOE determined the energy consumption for CWH equipment at different efficiency levels using the approach described previously in section IV.C.4 of this document.

4. Energy Prices

Electricity and natural gas prices are used to convert changes in the energy consumption from higher-efficiency equipment into energy cost savings. It is important to consider regional differences in electricity and natural gas prices because the variation in those prices can impact electricity and natural gas consumption savings and equipment costs across the country. In the May 2022 CWH ECS NOPR, DOE determined average effective commercial electricity prices[82] and commercial natural gas prices[83] at the State level from EIA data for calendar year 2019.

In response to the May 2022 CWH ECS NOPR, Joint Gas Commenters were critical of DOE's use of 2019 historical energy price data despite newer data being available "before the last update on March 25, 2022," and questioned why DOE did not update historical price data and marginal prices to match other base year costs. (Joint Gas Commenters, No. 34 at p. 23) In response, DOE chose 2019 as the base year in the May 2022 CWH ECS NOPR because it was the last calendar year for which complete natural gas and electricity data were available (*i.e.*, there were no missing data in the Natural Gas Navigator dataset), and at the time the United States had not begun to recognize that the Nation was in a period of rapid price inflation. For the final rule, DOE agrees with the Joint Gas Commenters that it is important to have fuel prices that are fully contemporaneous with the other base-year prices used in the analysis, such as the prices for stainless steel venting. For the final rule, DOE is using a 12-month period ending with December 2022.

For the final rule DOE again used data from EIA's Form 861[84] to calculate commercial and residential sector electricity prices, and EIA's Natural Gas Navigator to

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[82] U.S. Energy Information Administration (EIA). Form EIA-861M monthly electric utility Sales and Revenue Data (aggregated: 1990–current). Available at *www.eia.gov/electricity/data/eia861m/*. Last accessed on March 31, 2023.
[83] U.S. Energy Information Administration (EIA). Natural Gas Prices. Available at *www.eia.gov/dnav/ng/ng_pri_sum_a_EPG0_PCS_DMcf_a.htm*. Last accessed on March 31, 2023.
[84] U.S. Energy Information Administration (EIA). Uses prices presented in the Sales and Revenue report, by sector by state. The EIA-861M detailed data was the March 27, 2023 updated historical data containing data from 2010 through January 2023.

calculate commercial and residential sector natural gas prices.[85] Future energy prices were projected using trends from the EIA's *AEO2023*.[86] This approach captured a wide range of commercial electricity and natural gas prices across the United States.

CBECS and RECS report data based on different geographic scales. The various States in the United States are aggregated into different geographic scales such as Census Divisions (for CBECS) and Reportable Domains (for RECS). For both the commercial and residential sectors, DOE continued to use population in each State and the cumulative population in the States that comprise each Census Division and Reportable Domain for developing natural gas prices. See appendix 8C of the final rule TSD for further details.

The electricity and natural gas price trends provide the relative change in electricity and natural gas costs for future years. DOE used the *AEO2023* Reference case to provide the default electricity and natural gas price forecast scenarios. This is an update from the May 2022 CWH ECS NOPR that relied on the *AEO2021*. DOE extrapolated the trend in values at the Census Division level to establish prices beyond 2050.

Joint Gas Commenters criticized the use of AEO forecasts, claiming they have systematically overstated future energy costs, and presented a comparison of historical residential and commercial gas prices to AEO forecasts going back to 2010 to support

[85] U.S. Energy Information Administration (EIA). Natural Gas Navigator. Available at *www.eia.gov/dnav/ng/ng_pri_sum_a_EPG0_PRS_DMcf_a.htm*. Last accessed March 31, 2023.
[86] U.S. Energy Information Administration (EIA). Annual Energy Outlook 2023 with Projections to 2050: Narrative. March 2023. Available at *www.eia.gov/outlooks/aeo/*.

their claim. (Joint Gas Commenters, No. 34 at pp. 19–23) DOE uses the AEO forecast because it is the most widely available, widely reviewed and robust forecasting process available to DOE. As Joint Gas Commenters did not propose any alternative, let alone one as widely reviewed and robust as the AEO, DOE determined that the appropriate alternative at this point is to continue to use the AEO for future energy price trends, consistent with its practice in energy conservation standards rulemakings, with the only change made from the May 2022 CWH ECS NOPR being to update from the *AEO2021* to the *AEO2023*.

DOE developed the LCC analysis using a marginal fuel price approach to convert fuel savings into corresponding financial benefits for the different equipment categories. This approach was based on the development of marginal price factors for gas and electric fuels based on historical data relating monthly expenditures and consumption. For details of DOE's marginal fuel price approach, see chapter 8 of the final rule TSD.

Regarding the usage of EIA data for development of marginal energy costs and comparisons to tariff data, DOE emphasizes that the EIA data provide complete coverage of all utilities and all customers, including larger commercial and industrial utility customers that may have discounted energy prices. The actual rates paid by individual customers are captured and reflected in the EIA data and are averaged over all customers in a state. DOE has previously compared these two approaches for determining marginal energy price factors in the residential sector. In a September 2016 SNOPR for residential furnaces, DOE compared its marginal natural gas price approach using EIA data with marginal natural gas price factors determined from residential tariffs submitted by stakeholders. 81 FR 65719, 65784 (Sept. 23, 2016). The submitted tariffs represented only a small subset of utilities and States and were not nationally representative, but DOE found that its marginal price factors were generally comparable to those computed from the tariff data (averaging across rate tiers).[87] DOE noted that a full tariff-based analysis would require information on each household's total baseline gas consumption (to establish which rate tier is applicable) and how many customers are served by a utility on a given tariff. These data were not available in the public domain. By relying on EIA data, DOE noted, its marginal price factors represented all utilities and all States, averaging over all customers, and was therefore "more representative of a large group of consumers with diverse baseline gas usage levels than an approach that uses only tariffs." 81 FR 65719, 65784. While the above comparative analysis was conducted for residential consumers, the general conclusions regarding the accuracy of EIA data relative to tariff data remain the same for commercial consumers. DOE uses EIA data for determining both residential and commercial electricity prices and the nature of the data is the same for both sectors. DOE further notes that not all operators of CWH equipment are larger load utility customers. As reflected in the building sample derived from CBECS 2018 and RECS 2009 data, there is a range of buildings with varying characteristics, including multi-family residential buildings, that operate CWH equipment. The buildings in the LCC sample have varying hot water heating load, square footage, and water heater capacity. Operators of CWH equipment are varied, some large

[87] *See* appendix 8E of the TSD for the 2016 supplemental notice of proposed rulemaking for residential furnaces for a direct comparison, available at: *www.regulations.gov/document/EERE-2014-BT-STD-0031-0217* (Last accessed January 25, 2022).

and some smaller, and thus the determination of the applicable marginal energy price should reflect the average CWH equipment operator.

DOE's approach is based on the largest, most comprehensive, most granular national data sets on commercial energy prices that are publicly available from EIA. The data from EIA are the highest quality energy price data available to DOE. The resulting estimated marginal energy prices represent an average across all commercial customers in a given region (reportable domain for RECS, census division for CBECS). Some customers may have a lower marginal energy price, while others may have a higher marginal energy price. With respect to large customers who may pay a lower energy price, no tariffs were submitted to DOE during the rulemaking for analysis. Tariffs for individual non-residential customers can be very complex and generally depend on both total energy use and peak demand (especially for electricity). These tariffs vary significantly from one utility to another. While DOE was unable to identify data to provide a basis for determining a potentially lower price for larger commercial and industrial utility customers, either on a state-by-state basis or in a nationally representative manner, the historic data on which DOE did rely include such discounts. The EIA data include both large non-residential customers with a potentially lower rate as well as more typical non-residential customers with a potentially higher rate. Thus, to the extent larger consumers of energy pay lower marginal rates, those lower rates are already incorporated into the EIA data, which would drive down EIA's marginal rates for all consumers. If DOE were to adjust downward the marginal energy price for a small subset of individual customers in the LCC Monte Carlo, it would also have to adjust upward the marginal energy price for all other customers in the sample to maintain the same marginal energy price averaged over all customers. Even assuming DOE could accomplish those adjustments in a reliable or accurate way, this upward adjustment in marginal energy price would affect the majority of buildings in the LCC sample. Operational cost savings would therefore both decrease and increase for different buildings in the LCC sample, yielding substantially the same overall average LCC savings result as DOE's current estimate.

In summary, DOE's current approach utilizes an estimate of marginal energy prices and captures the impact of actual utility rates paid by all customers in a State, including those that enjoy lower marginal rates for whatever reason, in an aggregated fashion. Adjustments to this methodology are unlikely to change the average LCC results.

DOE uses EIA's forecasted energy prices to compute future energy prices indices (for this final rule, DOE updated forecasts from data published in the *AEO2023* Reference case), and combines those indices with monthly historical energy prices and seasonal marginal price factors in calculating future energy costs in the LCC analysis. For this final rule, DOE used 2022 EIA energy price data as a starting point. EIA historical price trends and calculated indices are developed in a reasonable manner using the best available data and models, and DOE uses these trends consistently across its regulatory analyses. DOE points out that this final rule analyzes potential new standards for gas-fired equipment, and that electricity usage for such commercial equipment occurs both during standby and during firing periods (depending on equipment design) and can occur during periods of utility peak usage. While electricity usage and resultant expenditures are significantly lower than fuel (gas)-related expenditures, they do impact the LCC analysis and have been included, using the calculated marginal electricity costs. DOE's use of marginal cost factors for electricity in this analysis, which is based on overall electric expenditures, including those associated with electricity demand, may result in somewhat higher electricity costs than cost figures that omit the impact of demand costs; however, this is appropriate for the current analysis, barring other information on commercial load profiles and demand-peak windows. After careful consideration during the preparation of this final rule, DOE concluded that it is appropriate to use its existing approach to the development of electric and fuel costs for the LCC and PBP analysis that (1) considers marginal electric and natural gas costs in its economic analysis, (2) reflects seasonal variation in marginal costs, and (3) uses EIA-recommended future energy price escalation rates. DOE maintained this approach for this final rule.

5. Maintenance and Repair Costs

Maintenance costs are the routine costs to the consumer of maintaining the operation of equipment. Repair costs are the cost to the consumer of replacing or repairing components that have failed in the CWH equipment.

a. Maintenance Costs

DOE utilized The Whitestone Facility Maintenance and Repair Cost Reference 2012–2013[88,89] to determine the amount of labor and material costs required for maintenance of each of the relevant CWH equipment subcategories. Maintenance costs include services such as cleaning the burner and flue and changing anode rods. DOE estimated average annual routine maintenance costs for each class of CWH equipment based on equipment groupings. Table IV.20 presents various maintenance services identified and the amount of labor required to service the equipment covered in the final rule analysis.

Table IV.20 Summary of Maintenance Labor Hours and Schedule Used in the LCC and PBP Analyses

Equipment	Description	Labor Hours	Frequency *years*
Commercial gas-fired storage water heaters; Residential-duty gas-fired storage water heaters	Clean (Volume ≤ 275 gallons)	2.67	1
	Clean (Volume > 275 gallons)	8	2
	Overhaul	1.84	5
Gas-fired instantaneous tankless water heaters	Service	0.75	1
Gas-fired instantaneous circulating water heaters and hot water supply boilers	Service	7.12	1

Because data were not available to indicate how maintenance costs vary with equipment efficiency, DOE used preventive maintenance costs that remain constant as

[88] Whitestone Research. The Whitestone Facility Maintenance and Repair Cost Reference 2012-2013 (17th Annual edition). 2012. Whitestone Research: Santa Barbara, CA.
[89] The Whitestone Research report is the most recent available from this source. The report was used in the determination of labor hours for maintenance, and DOE has found no evidence indicating that maintenance tasks and labor hours have changed except as addressed in subsequent sections of this final rule.

equipment efficiency increases. Additional information relating to maintenance of CWH equipment can be found in chapter 8 of the final rule TSD.

For the May 2022 CWH ECS NOPR, DOE did make revisions to some of the original Whitestone schedule of labor hour in response to comments on the withdrawn ECS NOPR. DOE added an additional 0.0833 labor hours per year[90] for checking condensate neutralizers during annual maintenance work, and $10 per year[91] for replacing the material within the neutralizers. In addition, DOE increased the labor hours for annual tankless water heater maintenance from 0.33 hours to 0.75 hours. DOE also conducted research on the maintenance labor activities and associated hours needed to maintain commercial gas-fired instantaneous circulating water heaters and hot water supply boilers. This research involved reviewing guidance in manufacturer product manuals in combination with the estimates in the Whitestone Facility Maintenance and Repair Cost Reference and the RSMeans Facilities Maintenance and Repair Cost Data.[92] Using these references, DOE updated the maintenance labor hours from 0.33 to 7.12 for this equipment category. Appendix 8E of the final rule TSD provides more detail on

[90] U.S. Department of Energy, Technical Support Document: Energy Efficiency Program for Consumer Products and Commercial and Industrial Equipment: Commercial Warm Air Furnaces. 2015. Docket No. EERE-2013-BT-STD-0021. The Commercial Warm Air Furnaces NOPR TSD assumed 0.078 hours for replacing neutralizer filler every 3 years. For this final rule, DOE used 5 minutes per year for checking and/or refilling neutralizers.

[91] A condensate neutralizer is used to buffer or neutralize the acidic content of flue gas condensate before disposal. The condensate neutralizer DOE included in DOE's installation costs weighs approximately 5 pounds. It is essentially a plastic tube with water inlet and outlet, and filled with calcium carbonate pellets (neutralizer media), and DOE estimates the pellets comprise 3.5 to 4 pounds of the total. DOE found prices ranging from $0.25 per pound (*phoenixphysique.com/ism-root-pvlsc/91da02-marble-chips-for-condensate-neutralizer)* up to $3 per pound in smaller purpose products. DOE estimates $10 per year would be sufficient to cover replacement of the pellets.

[92] RSMeans Company. Facilities Maintenance and Repair Cost Data 2022. 29th Annual Edition. Available at *www.rsmeans.com/products/books/*.

maintenance labor hours assigned to each equipment category of commercial water heaters.

In response to the May 2022 CWH ECS NOPR, Bradford White stated that DOE assumed that annual maintenance costs do not vary as a function of efficiency and recommended that this assumption be updated as burner maintenance costs increase as a function of efficiency. (Bradford White, No. 23 at p. 8) In response to this comment, DOE downloaded Bradford White and Lochinvar installation and operation manuals for commercial gas-fired condensing and non-condensing water heaters. DOE compared the language for maintenance for burners. While clearly the burners appeared different in the pictures in the manuals, the language for this step was identical. Because DOE could not discern where additional steps needed to be taken involving additional time, and because Bradford White did not volunteer this information in their comment, DOE did not add additional labor hours in response to this comment.

In another comment on the May 2022 CWH ECS NOPR, JJM Alkaline noted the costs to replace neutralizers ($10/year) is below prevailing market costs. (JJM Alkaline, No. 10 at p. 1) DOE reviewed the cost assumptions and inputs used in the modeling of condensate management solutions. DOE reviewed costs for condensate neutralizer material (based on retail prices available for different purchase quantities), condensate neutralizers, as well as considerations for labor. DOE also considered how consumption of neutralizer media would change between different water heating equipment by input capacity, full load operating hours as evidenced in its LCC analysis and subsequent overall condensate production. DOE's revised analysis resulted in increased costs overall, but more specifically made overall condensate management costs a function of each representative equipment type in DOE's analysis. Labor cost was doubled from 5 minutes to 10 minutes per year, and is assumed to take place at the time of a normal maintenance cycle. Both the assumed prevalence of condensate neutralization equipment and the expected cost of such equipment are discussed in chapter 7 of the final rule TSD.

b. Repair Costs

DOE calculated CWH repair costs based on an assumed typical failure rate for key CWH subsystems. DOE assumed a failure rate of 0.5 percent per year for combustion systems, 1 percent per year for controls, and 2 percent per year for high efficiency controls applied with condensing equipment. This probability of repair is assumed to extend through the life of the equipment, but only one major repair in the life of the equipment was considered.

The labor required to repair a subsystem was estimated as 2 hours for combustion systems and 1 hour for combustion controls. Labor costs are based upon servicing by one plumber with overhead and profit included and are based on RSMeans data.[93] Because a repair may not require the complete subsystem replacement, but rather separate components, DOE estimated a typical repair would have material costs of one-half the subsystem total cost, but would require the equivalent labor hours for total subsystem replacement. DOE calculated a cost for repair over the life of a CWH unit with these assumptions, and used that cost or repair in the analysis. A repair year was selected at

[93] RSMeans. RSMeans Mechanical Costs Book 2022. Available at *www.rsmeans.com/products/books.*

random over the life for each unit selected in the LCC and the repair cost occurring in that year was discounted to present value for the LCC analysis.

Heat exchanger failure is a unique repair scenario for certain commercial gas-fired instantaneous circulating water heaters and hot water supply boilers and was included in DOE's repair cost analysis. The use of condensing or non-condensing technology determines the rate and timing of heat exchanger failure as well as the cost of repair with an approximately three times greater probability of repair for condensing equipment. DOE's assumptions for the frequency of failure and the mean year of heat exchanger failure were based on a report from the Gas Research Institute ("GRI") for boilers.[94] The cost of heat exchanger replacement is assumed to be a third of the total water heater replacement cost.

In the October 2014 RFI, DOE asked if repair costs vary as a function of equipment efficiency. 79 FR 62899, 62908 (Oct. 21, 2014). Four stakeholders commented on the relationship between equipment efficiency and repair costs, with emphasis that higher-efficiency equipment incorporates additional components and more complex controls. (Bradford White, No. 3 at p. 3; A.O. Smith, No. 2 at p.4; AHRI, No. 5 at p. 5; Rheem, No. 10 at p.7) DOE considered the feedback from the stakeholders and

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[94] Jakob, F. E., J. J. Crisafulli, J. R. Menkedick, R. D. Fischer, D. B. Philips, R. L. Osbone, J. C. Cross, G. R. Whitacre, J. G. Murray, W. J. Sheppard, D. W. DeWirth, and W. H. Thrasher. *Assessment of Technology for Improving the Efficiency of Residential Gas Furnaces and Boilers*. Volume I and II – Appendices. September 1994, 1994. Gas Research Institute. AGA Laboratories: Chicago, IL. Report No. GRI-94/0175.

undertook further research to identify components and subsystems commonly replaced in order to evaluate differences in repair costs relative to efficiency levels.

As a result of its research, DOE learned that the combustion systems and controls used in gas-fired CWH equipment have different costs related to the efficiency levels of these products, a finding in agreement with comments provided on the RFI. For the combustion systems, these differences relate predominately to atmospheric combustion, powered atmospheric combustion, and pre-mixed modulating combustion systems used on baseline-efficiency, moderate-efficiency, and high-efficiency products respectively. The control systems employed on atmospheric combustion systems were found to be significantly less expensive than the controller used on powered combustion systems, which was observed to include a microprocessor in some products.

Where similar component parts and costs were identified that reflected the equipment category and efficiency, DOE's component cost was estimated as the average cost of those replacement components identified. This cost was applied at the frequency identified earlier in this section. DOE understands that this approach may conservatively estimate the total cost of repair for purposes of DOE's analysis, but the percentage of total repair cost remains small compared to the consumer cost and the total installation cost. Additionally, DOE prefers to use this component-level approach to understand the incremental repair cost difference between efficiency levels of equipment. Additional details of this analysis and source references for the subsystem and component costs are found in chapter 8 of the final rule TSD and appendix 8E of the final rule TSD. DOE's incorporation and approach to repair costs in the LCC did not change from the NOPR implementation.

Bradford White recommended DOE investigate other sources of more recent data on heat exchanger failure, noting that DOE bases its assumptions on heat exchanger failure based on a Gas Research Institute report on boilers, not water heaters, and it is from 1994. (Bradford White, No. 23 at p. 8) DOE understands Bradford White's concerns about this source document, and DOE invested a considerable amount of time investigating whether alternative information sources existed, and none could be identified. Thus for this final rule, DOE continues to rely upon this as the best available information.

Joint Gas Commenters note DOE, without reference or logic, assumes the cost of heat exchanger replacement, where possible, is one third of the total water heater replacement cost. They also state it is just as likely that heat exchanger failure will cause a need for complete replacement of the water heating equipment, but the added negative economic impact of more frequent equipment outages on the business's operation is not considered. (Joint Gas Commenter, No. 34 at p. 19) DOE notes that appendix 8E in both the May 2022 CWH ECS NOPR and the final rule TSDs outlines heat exchanger replacement assumptions. The estimated cost equivalent to one-third of the hot water supply boiler cost was based on manufacturer literature. Based on the aforementioned Gas Research Institute report, DOE assumes that as many as 50 percent of condensing heat exchangers will need to be replaced with an average year of failure of 15 years. Note that for hot water supply boilers and other instantaneous water heaters, DOE assumes a 25 year lifetime. DOE also assumes 17 percent of non-condensing heat exchangers in those units will need to be replaced with a mean year of failure of 20 years, again for equipment with an expected 25 year lifetime. Thus, on average, a non-condensing heat exchanger failure could lead to more premature circulating water heaters and hot water supply boiler replacements because, on average, the heat exchanger replacement would occur closer to the expected end of life of the hot water supply boiler and consumers' repair professionals would make them aware of how much expected life would be available after the repair. DOE also notes that economically rational consumers are not going to replace a serviceable and repairable condensing hot water supply boiler that costs in excess of $7,100 if the heat exchanger fails at year 15. They would only do such if the water heater is otherwise compromised. As for the impact on a consumer's business, DOE has no mechanism for determining what if any impact there would be on a consumer's business. As discussed in IV.F.2.h, consumers have many alternatives for minimizing or mitigating downtime. While DOE is basing the assumptions of heat exchanger replacement on the best available data, Bradford White is correct in noting the Gas Research Institute report is from 1994, and DOE would assume that in normal situations, manufacturers would have made progress in reducing the failure rate since that date. When viewed in this light, the inclusion of this higher failure rate might be a conservative assumption.

6. Product Lifetime

For CWH equipment, DOE used lifetime estimates derived through a review of numerous sources. Product lifetime is the age when a unit of CWH equipment is retired from service. For the May 2022 CWH ECS NOPR and for this final rule, DOE used a distribution of lifetimes, with the weighted averages ranging between 10 years and 25 years as shown in Table IV.21, which are based on a review of CWH equipment lifetime estimates found in published studies and online documents. These sources used by DOE in the review of lifetime include documents from prior DOE efficiency standards rulemaking processes, LBNL, NREL, the EIA, Federal Energy Management Program, Building Owner and Managers Association, Gas Foodservice Equipment Network, San Francisco Apartment Association, and National Grid.[95] Specific document titles and references are provided in appendix 8F of the final rule TSD. DOE applied a distribution to all classes of CWH equipment analyzed. Chapter 8 of the final rule TSD contains a detailed discussion of CWH equipment lifetimes.

Table IV.21 Average CWH Lifetime Used in Final Rule Analyses

<table>
<tr><th colspan="2">CWH Equipment</th><th>Average Lifetime
years</th></tr>
<tr><td colspan="2">Commercial gas-fired storage water heaters and storage-type instantaneous</td><td>10</td></tr>
<tr><td colspan="2">Residential-duty gas-fired storage water heaters</td><td>12</td></tr>
<tr><td rowspan="2">Gas-fired instantaneous water heaters and hot water supply boilers</td><td>Tankless water heaters</td><td>17</td></tr>
<tr><td>Circulating water heaters and hot water supply boilers</td><td>25</td></tr>
</table>

DOE notes that the average lifetime of all equipment covered by this rulemaking is the same for baseline and max-tech thermal efficiency levels. The lifetime selected for each simulation run varies, but the weighted-average lifetime is the same across all thermal efficiency levels.

[95] DOE attempted to only include only unique sources, as opposed to documents citing other sources already included in DOE's reference list.

In response to the May 2022 CWH ECS NOPR, DOE received several comments concerning the estimated lifetime of equipment. AHRI stated that 10 years for commercial gas storage and 25 years for Instantaneous Water Heaters and Hot Water Supply Boilers seem more characteristic of residential applications than commercial. Higher water temperatures and faster duty cycles decrease expected lifetimes. (AHRI, No. 31 at p. 1) Rheem supported this AHRI comment. (Rheem, No. 24 at p. 2) Similarly, Bradford White stated that DOE's assumed 10-year life for commercial gas-fired storage and 25-year life for gas-fired instantaneous and hot water supply boilers are almost the same (in the case of gas-fired storage), or more than, their consumer (*i.e.*, residential) counterparts. Bradford White also reiterated the point AHRI made about temperatures and duty cycles. Bradford White further noted that in appendix 8F, DOE cited experts stating commercial water heaters are expected to have shorter lives than residential water heaters. They expressed concern that DOE referenced several sources more than 10 years old. (Bradford White, No. 23 at pp. 2 and 5) PHCC also stated DOE's lifetimes are too long, and DOE's listed lifetimes would be the maximum age for products, not the average age. PHCC notes that their members do not have a complied database for these products to verify life and that DOE should reengage with the product manufacturers and other stakeholders to see if additional data can be developed. (PHCC, No. 28 at p. 6) Joint Gas Commenters noted DOE assumes that the lifetime distribution for a class of CWH unit is the same within an equipment category, across all efficiency levels, then points to the replacement of boiler heat exchangers implying that lower reliability of heat exchangers in condensing units compared to non-condensing units should imply shorter life. (Joint Gas Commenters, No. 34 at page 19)

In response, DOE notes that the residential (*i.e.*, consumer) gas water heaters are estimated to have a 14.5 year life, which exceeds both the commercial gas storage water heaters lifetime (10 years) and residential-duty gas-fired storage water heater lifetime (12 years).[96] Consumer boilers are estimated to have a 26.6 year lifetime, or 1.6 years longer than the lifetime for hot water supply boilers and circulating water heaters assumed by DOE.[97] Thus, DOE's estimated equipment lifetimes for commercial water heaters are shorter than the residential counter-parts. DOE notes that the commercial gas-fired storage water heater lifetime is approximately 30 percent shorter than its residential counterpart while the commercial hot water supply boiler lifetime is 6 percent shorter than its residential boiler counterpart. Bradford White, AHRI and Rheem did not provide DOE with sufficient numerical data concerning CWH equipment lifetimes to justify a significantly greater disparity in the lifetimes between these CWH and residential equipment. In response to the age of the documents cited in DOE's review of research on CWH equipment lifetimes, DOE undertook an additional literature search to determine if newer information was available. The search turned up newer documents with information about CWH equipment lifetime, but virtually all such documents refer to the sources cited in the NOPR for the lifetimes that they state. Thus, while the NOPR list of citations includes many older documents, updating this literature review did not provide evidence leading DOE to conclude that a change was needed in any of the estimated lifetimes.

[96] Based on the average lifetime included in DOE's ongoing consumer water heater rulemaking EERE-2017-BT-STD-0019.
[97] Based on the average lifetime included in DOE's ongoing consumer boiler rulemaking, Preliminary Technical Support Document, from *www.regulations.gov/document/EERE-2019-BT-STD-0036-0021*.

In response to the Joint Gas Commenters, DOE does not have data to suggest that the lifetime of condensing CWH equipment is lower than that of non-condensing equipment; rather, all available data suggests that the lifetime of condensing CWH equipment is substantially the same as noncondensing CWH equipment. DOE does have and has incorporated data regarding increased repair costs for individual component failures that may occur in higher-efficiency equipment, as discussed in section IV.F.5.b of this document. However, the increased repair costs are largely related to the increased component cost and even in the case of heat exchangers where DOE cites a higher failure rate, such does not translate directly to decreased product life. While Joint Gas Commenters remark about heat exchanger failure leading to early replacement of the entire water heater, DOE would note that CWH equipment has a rather high total installed cost and it would not be in consumers economic best interest to replace an otherwise serviceable and repairable water heater. As noted in both the May 2022 CWH ECS NOPR and the Final Rule TSD appendix 8E, DOE assumes a mean failure year of 15 years for condensing heat exchangers which, when combined with the original warranty period, means there is no reason to expect the heat exchanger repair work to automatically result in a shorter lifetime.

7. Discount Rates

In the calculation of LCC, DOE applies appropriate discount rates to estimate the present value of future operating costs. DOE determined the discount rate by estimating the cost of capital for purchasers of CWH equipment. Most purchasers use both debt and equity capital to fund investments. Therefore, for most purchasers, the discount rate is the weighted-average cost of debt and equity financing, or the weighted-average cost of capital ("WACC"), less the expected inflation.

For residential consumer purchase of CWH equipment, DOE applies weighted average discount rates calculated from consumer debt and asset data, rather than marginal or implicit discount rates.[98] DOE notes that the LCC does not analyze the equipment purchase decision, so the implicit discount rate is not relevant in this model. The LCC estimates net present value over the lifetime of the equipment, 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, 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 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.

For commercial purchasers, to estimate the WACC DOE used a sample of detailed business sub-sector statistics, drawn from the database of U.S. companies presented on the Damodaran Online website.[99] This database includes most of the

[98] 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.
[99] *Damodaran Online*. Damodaran financial data used for determining cost of capital. Available at *pages.stern.nyu.edu/~adamodar/*. Last accessed on December 20, 2022.

publicly-traded companies in the United States. Using this database, Damodaran developed a historical series of sub-sector-level annual statistics for 100+ business sub-sectors. Using data for 1998–2021, inclusive, DOE developed sub-sector average WACC estimates, which were then assigned to aggregate categories. For commercial water heaters, the applicable aggregate categories include retail and service, property/real-estate investment trust ("REIT"), medical facilities, industrial, hotel, food service, office, education, and other. The WACC approach for determining discount rates accounts for the applicable tax rates for each category. DOE did not evaluate the marginal effects of increased costs, and, thus, depreciation due to more expensive equipment, on the overall tax status.

DOE used the sample of business sub-sectors to represent purchasers of CWH equipment. For each observation in the sample, DOE derived the cost of debt, percentage of debt financing, and cost of equity from industry-level data on the Damodaran Online website, from long-term nominal S&P 500 returns also developed by Damodaran, and risk-free interest rates based on nominal long-term Federal government bond rates. DOE then determined the weighted-average values for the cost of capital, and the range and distribution of values of WACC for each of the sample business sectors. Deducting expected inflation from the cost of capital provided estimates of the real discount rate by ownership category.

For most educational buildings and a portion of the office buildings occupied by public schools, universities, and State and local government agencies, DOE estimated the cost of capital based on a 40-year geometric mean of an index of long-term tax-exempt municipal bonds (>20 years).[100,101] Federal office space was assumed to use the Federal bond rate, derived as the 40-year geometric average of long-term (>10 years) U.S. government securities.[102]

Based on this database, DOE calculated the weighted-average, after-tax discount rate for CWH equipment purchases, adjusted for inflation, made by commercial users of the equipment.

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 Survey of Consumer Finances ("SCF")[103] for 1995, 1998, 2001, 2004, 2007, 2010, 2013, 2016, and 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. In the Crystal Ball™ analyses, when an LCC model selects a residential observation, the model selects an income group and then selects a discount rate from the

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[100] Federal Reserve Bank of St. Louis. State and Local Bonds - Bond Buyer Go 20-Bond Municipal Bond Index. Data available through 2015 at *research.stlouisfed.org/fred2/series/MSLB20/downloaddata?cid=32995*. Last accessed April 3, 2020.
[101] Bartel Associates, LLC. *Ba 2019-12-31 20 Year AA Municipal Bond Rates.* Averaged quarterly municipal bond rates to develop annual averages for 2016–2020. *bartel-associates.com/resources/select-gasb-67-68-discount-rate-indices*. Last accessed on June 23, 2022.
[102] Rate calculated with rolling 40-year data series for the years 1992 – 2021. Data source: U.S. Federal Reserve. Available at *www.federalreserve.gov/releases/h15/data.htm*. Last accessed on July 12, 2022.
[103] Board of Governors of the Federal Reserve System. Survey of Consumer Finances. Available at *www.federalreserve.gov/PUBS/oss/oss2/scfindex.html*.

distribution for that group. Chapter 8 of the final rule TSD contains the detailed calculations related to discount rates.

Use of discount rates in each section of the analysis is specific to the affected parties and the impacts being examined (*e.g.*, LCC: consumers, MIA: manufacturers; NIA: national impacts using OMB-specified discount rates), consistent with the general need to examine these impacts independently. In addition, where factors indicate that a range or variability in discount rates is an important consideration and can be or is provided, DOE uses a range of discount rates in its various analyses.

For this final rule, DOE examined its established process for development and use of discount rates and has concluded that it sufficiently characterizes the discount rate facing consumers.

Patterson-Kelley suggested that both State and local consumers and small businesses need to be better included in the analysis. (Patterson-Kelley, No. 26 at p. 2) DOE notes that CBECS is a nationally representative sample of activity in buildings used for commercial activities, and for activities of state and local governments and government enterprises such as local school districts or state colleges or universities. In the CBECS 2018 database, 1,407 of 6,436 buildings are coded as either state government ownership or local government owned buildings. Because there is no data field in CBECS that indicates "small business," there is no reliable way to identify a specific building as being small business. However, the CBECS dataset includes representative numbers of buildings in business sectors commonly thought of as small businesses, such as “mom and pop” restaurants, retail establishments or motels, and other buildings that could be considered small business according to the U.S. Small Business Administration. Accordingly, DOE believes its analysis sufficiently includes state and local consumers and small businesses.

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 conservation standards).

To estimate the energy efficiency distribution of CWH equipment for 2026, DOE developed the no-new-standards distribution of equipment using data from DOE’s Compliance Certification database and data submitted by AHRI regarding condensing versus non-condensing equipment.

Each building in the sample was then assigned a water heater efficiency sampled from the no-new-standards-case efficiency distribution for the appropriate equipment class, shown at the end of this section. DOE was not able to assign a CWH efficiency to a building in the no-new-standards case based on building characteristics, since CBECS 2018 and RECS 2009 did not provide enough information to distinguish installed water heaters disaggregated by efficiency. The efficiency of a CWH was assigned based on the forecasted efficiency distribution (which is constrained by the shipment and model data collected by DOE and submitted by AHRI) and accounts for consumers that are already purchasing efficient CWHs.

Joint Advocates stated DOE's use of the assignment of efficiency levels in the no-new-standards case is sufficiently representative of consumer behavior. Joint Advocates noted the examples of market failures such as misaligned incentives in landowner-renter situations, and these market failures result in under-investment in energy efficiency and consumers not making decisions that result in the highest net present value in their specific situations. Joint Advocates stated that DOE's assignment of efficiency levels in the no-new-standards case reasonably reflects actual consumer behavior. Joint Advocates disagreed with Barton Day Law's comment during the Public Meeting regarding random assignment (discussed later in this section). Joint Advocates stated that market failures in commercial and industrial sectors add complexity to the decision-making process and result in an under-investment in energy efficiency. (Joint Advocates, No. 29 at p.3) CA IOUs supported DOE's robust analysis of the no-new-standards case and the consumer choice model. Like many utilities across the country, the CA IOUs implement a statewide energy efficiency program for commercial water heating to manage these [market] barriers directly. The CA IOUs stated DOE's review of failures in the commercial market presented in the May 2022 CWH ECS NOPR is consistent with their understanding. They stated DOE's analysis is thoughtful, robust, and well within its regulatory discretion. (CA IOUs, No. 33 at p. 5) NYSERDA supported DOE's estimates of efficiency levels in the no-new-standards case and stated that DOE's estimates are well-reasoned and based on the most relevant data. In particular, NYSERDA stated that DOE's use of Compliance Certification Database and AHRI data is a thorough analysis that provides a well-founded estimate. NYSERDA indicated that market data do not reflect the assumption that purchasers of CWH equipment are only basing their decisions on economics. NYSERDA stated they implement a wide variety of programs to help spur market transformation, and these efforts seek to address the specific types of market failures that DOE addresses in its analysis. (NYSERDA, No. 30 at pp. 2–3) DOE acknowledges these comments and the references to market failures being addressed by market transformation programs. As a reminder the list of market failures discussed in the May 2022 CWH ECS NOPR is included in this section after the comments are addressed.

Joint Gas Commenters criticized DOE's use of random assignments of baseline efficiency, stating that consumers who find condensing to be cost effective have already installed it and for those who have not installed it, it is likely not cost effective. Joint Gas Commenters went on to state that the random assignment of efficiencies assumes that purchasers of commercial water heaters never consider the economics of their purchases. Joint Gas Commenters went on to state that DOE's use of random assignment is most unreasonable when it results in large LCC savings. (Joint Gas Commenters, No. 34 at pp. 21–22 and 23–25) Barton Day Law asked about the distribution of extreme outcomes resulting from random assignment, stating that extreme outcomes have a disproportionate impact on the average LCC results. Barton Day Law offered the opinion that DOE should look at the impact of the extreme outcomes, and random assignment of outcomes where the more efficient product is the low-cost option should be in the base case for the analysis. (Barton Day Law, Public Meeting Transcript, No. 13 at pp. 51–55) Joint Gas Commenters pointed to the National Academy of Sciences 2021 review of DOE's standards process and to the D.C. Circuit's opinion in *APGA v. DOE* (22 F.4th 1018 to 1027) to support their comments. They further referred to the literature cited in the May 2022 CWH ECS NOPR discussing market failure and offer their opinion that such information provides no basis to conclude that purchasers are not acting in their economic interest when they make a decision to purchase or not purchase condensing equipment. (Joint Gas Commenters, No. 34 at p. 30) Similarly, Atmos Energy stated DOE's analysis does not consider key consumer decision-making aspects such as hot water demand, building design impacts on installation costs, and "realistic" maintenance and repair costs, as well as rebate costs. They noted that DOE does not use a "discrete choice model" or rely on "sufficient collected data on consumer behavior." (Atmos Energy, No. 36 at p. 4)

DOE first notes that, with respect to the National Academy of Sciences report, the recommendations will be evaluated in a separate proceeding. With respect to the D.C. Circuit's opinion in *APGA v. DOE*, 22 F.4th 1018 (*APGA I*), DOE notes that the random assignment issue raised in that litigation was further addressed by DOE through the final rule for the commercial packaged boiler ("CPB") ECS rulemaking (EERE-2013-BT-STD-0030),[104] and while the court in *APGA v. DOE*, No. 22-1107, 2023 WL 4377914 (D.C. Cir. July 7, 2023) (*APGA II*) vacated the rule on other grounds, it did not address the merits of arguments on random assignment raised by petitioner. In developing the May 2022 CWH ECS NOPR and ultimately this final rule, DOE took into account all of

[104] *See* Energy Conservation Program: Energy Conservation Standards for Commercial Packaged Boilers; Response to United States Court of Appeals for the District of Columbia Circuit Remand *in American Public Gas Association v. United States Department of Energy, www.govinfo.gov/content/pkg/FR-2022-04-20/pdf/2022-08427.pdf.*

the available data concerning the market implementation of condensing natural gas-fired CWH equipment. As shown in the table at the end of this section (Table IV.22), using actual data from AHRI for a period ending 2015, S-curves developed from the AHRI data, CCMS and other data, DOE projected CWH shipments by efficiency level over the analysis period. DOE then determined that, based on the presence of well-understood market failures and a corresponding lack of data showing a correlation between CWH efficiency and building hot water load, a random assignment of efficiencies best accounts for consumer behavior in the CWH market.

Further, DOE strongly disagrees with the statement from Joint Gas Commenters that this methodology assumes that purchasers of CWHs never consider the economics of their investments. Rather, as explained in the remainder of this section, DOE is aware of multiple market failures that prevent the purely economic decision making hypothesized by the Joint Gas Commenters. That being said, DOE uses a random assignment because it does reflect the full range of consumer behaviors, including those consumers who make purely economic decisions, found in the CWH market. As reflected in the LCC analysis, a significant portion (63 to 69 percent depending on product class) of buildings with large hot water loads were assigned more efficient CWHs.

DOE also finds Joint Gas Commenters and Barton Day Law's focus on trial cases with large LCC savings to be misguided. Commenters cite these cases as evidence that random assignment results in unreasonable results that disproportionately affect DOE's analysis. But as mentioned previously and discussed in more detail below, DOE used a random assignment because of well-understood market failures. Commenters seem to be suggesting that these market failures should not apply to situations where purchasing decisions have larger economic impacts. DOE does not agree. For example, one well-understood market failure is where a building owner purchases the CWH, but the tenant pays the utility bills. DOE sees no reason to assume that this market failure does not occur, or is less likely to occur, when the building has a larger hot water load, i.e., the economic impacts are larger.

As stated previously, DOE believes that, based on the presence of well-understood market failures and a corresponding lack of data showing a correlation between CWH efficiency and building hot water load, a random assignment of efficiencies best accounts for consumer behavior in the CWH For these reasons, DOE rejects the approach recommended by Barton Day Law, Joint Gas Commenters, and Atmos Energy, and DOE continues to use the approach for selecting the baseline efficiency level that was used for the May 2022 CWH ECS NOPR.

While DOE acknowledges that economic factors play a role when building owners or builders decide on what type of CWH to install, assignment of CWH efficiency for a given installation, based solely on economic measures such as LCC or simple PBP, most likely would not fully and accurately reflect actual real-world installations. There are a number of commercial sector market failures discussed in the economics literature, including a number of case studies, that illustrate how purchasing decisions with respect to energy efficiency are likely to not be completely correlated with energy use, as described next.

There are several market failures or barriers that affect energy decisions generally. Some of those that affect the commercial sector specifically are detailed below. However, more generally, there are 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 these are presented for any given choice scenario.[105] 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 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.[106] 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.[107] These characteristics describe almost all purchasing situations of appliances and equipment, including commercial water heaters. The installation of a new or replacement CWH in a commercial building is a complex, technical decision

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[105] Thaler, R.H., Sunstein, C.R., and Balz, J.P. (2014). "Choice Architecture" in *The Behavioral Foundations of Public Policy*, Eldar Shafir (ed).
[106] 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).
[107] Thaler, R.H., and Sunstein, C.R. (2008). *Nudge: Improving Decisions on Health, Wealth, and Happiness*. New Haven, CT: Yale University Press.

involving many actors and is done very infrequently, as evidenced by the CWH mean lifetime of up to 25 years.[108] Additionally, it would take multiple billing cycles for any impacts on operating costs to be fully apparent. Further, if the purchaser of the commercial 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. These behavioral factors are in addition to the more specific market failures described as follows.

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.

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.[109, 110] Indeed, a substantial fraction of commercial buildings with a commercial water heater in the CBECS 2018 sample are

[108] American Society of Heating, Refrigerating, and Air-Conditioning Engineers. *2011 ASHRAE Handbook: Heating, Ventilating, and Air-Conditioning Applications.* 2011. Available at *www.ashrae.org/resources--publications*. Last accessed on October 16, 2016.

[109] 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.

[110] 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 20, 2022).

occupied at least in part by a tenant, not the building owner (indicating that, in DOE's experience, the building owner likely 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 commercial 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.[111] 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.[112] Decision-making related to commercial buildings is highly complex and involves gathering information from and for a variety of 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.[113]

[111] 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).
[112] 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).
[113] 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 20, 2022)

Second, the nature of the organizational structure and design can influence priorities for capital budgeting, resulting in choices that do not necessarily maximize profitability.[114] 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.[115] U.S. tax rules for commercial buildings may incentivize lower capital expenditures, since capital costs must be depreciated over many years, whereas operating costs can be fully deducted from taxable income or passed through directly to building tenants.[116]

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

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[114] 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.
[115] 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.
[116] Lovins, A. (1992). Energy-Efficient Buildings: Institutional Barriers and Opportunities. (Available at: *rmi.org/insight/energy-efficient-buildings-institutional-barriers-and-opportunities/*) (Last accessed December 19, 2022).

option.[117] Asymmetric information in financial markets is particularly pronounced with regard to energy efficiency investments.[118] 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,[119] which can bias firms toward 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 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.[120] 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

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[117] 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.
[118] Mills, E., Kromer, S., Weiss, G., and Mathew, P. A. (2006). "From volatility to value: analyzing 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.
[119] 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 December 19, 2022).
[120] Cooremans, C. (2012). "Investment in energy efficiency: do the characteristics of investments matter?" *Energy Efficiency*, 5(4), 497-518.

economically beneficial).[121] 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.[122]

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[123] and required PBPs of many firms are higher than the appropriate cost of capital for the investment.[124] The preceding arguments for the existence of market failures in the commercial and industrial sectors are corroborated by 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.[125] The study found that multiple organizational and institutional factors caused firms to require shorter PBPs and higher returns than the cost of capital for alternative investments of similar risk.

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[121] 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 December 19, 2022).
[122] 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 December 19, 2022).
[123] 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.
[124] DeCanio 1994, op. cit.
[125] DeCanio, S. J. (1998). "The Efficiency Paradox: Bureaucratic and Organizational Barriers to Profitable Energy-Saving Investments," *Energy Policy*, 26(5), 441-454.

Another study demonstrated similar results with firms requiring very short PBPs of 1–2 years in order to adopt energy-saving projects, implying hurdle rates of 50 to 100 percent, despite the potential economic benefits.[126] 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,[127] supermarkets,[128] and the electric motor market.[129]

The existence of market failures in the commercial and industrial sectors is well supported by the economics literature and by a number of case studies. If DOE developed an efficiency distribution that assigned commercial water efficiency in the no-new-standards case solely according to energy use or economic considerations such as LCC or PBP, 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 CWH market. Further, even if a specific building/organization is not subject to the market failures above, the purchasing decision of CWH efficiency can be highly complex and influenced by a number of factors not captured by the building characteristics available in the CBECS or RECS

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[126] 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.
[127] 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.
[128] 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.
[129] 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 20, 2022).

samples. These factors can lead to building owners choosing a CWH efficiency that deviates from the efficiency predicted using only energy use or economic considerations such as LCC or PBP (as calculated using the information from CBECS 2018 or RECS 2009).

DOE notes that EIA's [130] AEO is another energy use model that implicitly includes market failures in the commercial sector. In particular, the commercial demand module[131] includes behavioral rules regarding capital purchases such that in replacement and retrofit decisions, there is a strong bias in favor of equipment of the same technology (*e.g.*, water heater efficiency) despite the potential economic benefit of choosing other technology options. Additionally, the module assumes a distribution of time preferences regarding current versus future expenditures. Approximately half of the total commercial floorspace is assigned one of the two highest time preference premiums. This translates into very high discount rates (and hurdle rates) and represents floorspace for which equipment with the lowest capital cost will almost always be purchased without consideration of operating costs. DOE's assumptions regarding market failures are therefore consistent with other prominent energy consumption models.

Joint Gas Commenters also criticized DOE for failing to respond to the comments provided in the withdrawn 2016 CWH ECS NOPR on random assignment, referring to such as a violation of DOE's Basic Notice and Comment Obligations. (Joint Gas

[130] EIA, Annual Energy Outlook, *www.eia.gov/outlooks/aeo/* (Last accessed December 19, 2022).
[131] For further details, see: *www.eia.gov/outlooks/aeo/assumptions/pdf/commercial.pdf.* (Last accessed December 19, 2022).

Commenters, No. 34 at p. 28) Joint Gas Commenters stated that DOE cannot release a final rule without addressing the random assignment issues and cannot address them without giving stakeholders an opportunity to refute DOE's response during the rulemaking process—citing *Owner-Operator Indep. Drivers Ass'n v. FMCSA*, 494 F.3d 188, 202 (D.C. Cir. 2007). (Joint Gas Commenters, No. 34 at p. 31) As a threshold matter, DOE notes that nothing in EPCA or the Administrative Procedure Act (5 U.S.C. 551 *et seq*.) requires an agency to provide additional notice and comment on a withdrawn NOPR, or additional notice and comment before a final rule to allow commenters to refute the Department's responses to comments on a NOPR. As noted previously, DOE withdrew the 2016 CWH ECS NOPR and reissued a proposed rule for commercial water heaters in the May 2022 CWH ECS NOPR. In the May 2022 CWH ECS NOPR, DOE did address comments on the May 2016 CWH ECS NOPR, which caused DOE to materially change the analyses (beyond simply updating inputs) from the analyses performed for the withdrawn 2016 CWH ECS NOPR. In the May 2022 CWH ECS NOPR, DOE also addressed the fact that a considerable number of market failures could occur causing the strict economic decision making hypothesized by the Joint Gas Commenters to not be the sole guiding determinant of efficiency choices. DOE further addressed the Joint Gas Commenters comments about random assignments by explaining how DOE modeled the efficiency distributions and the data sources used in the NOPR. Additionally, in doing so, DOE provided stakeholders with a track record that could be followed to understand the differences in the 2016 and the 2022 LCC models. Notably, the model used for efficiency distribution in the no-new standards case in the May 2022

CWH ECS NOPR was substantially the same as the model used for the withdrawn May 2016 CWH ECS NOPR, and is substantially the same in this final rule.

Stakeholders have been provided with adequate notice and opportunity to comment on DOE's proposed rule. That DOE did not make the changes recommended by the commenter does not negate the adequacy of notice and comment. Stakeholders have been provided the same notice and opportunity to comment as they would have had DOE issued a final rule subsequent to the May 2016 CWH ECS NOPR. Nothing in EPCA or the Administrative Procedure Act (5 U.S.C. 551 *et seq*.) requires DOE to provide additional notice and comment before the final rule for its responses to comments on a NOPR.[132]

Accordingly, for the reasons stated in this section, DOE has maintained the approach used in the May 2022 CWH ECS NOPR for analyzing energy efficiency distribution in the no-new-standards case. The estimated market shares for the no-new-standards case for CWH equipment are shown in Table IV.22. See chapter 8 of the final rule TSD for further information on the derivation of the efficiency distributions.

[132] Joint Gas Commenters cite *Owner-Operator Indep. Drivers Ass'n v. FMCSA*, 494 F.3d 188, 202 (D.C. Cir. 2007) for the proposition that DOE must provide stakeholders an opportunity to refute DOE's responses during the rulemaking process. However, the court in that case did not state that an agency must allow stakeholders to refute its responses to comments on a NOPR as Joint Gas Commenters suggest. Rather, in that case, the D.C. Circuit held that the agency violated the notice-and-comment requirement of the Administrative Procedure Act when it promulgated a final rule with an update to a model used in the proposed rule that presented an entirely new methodology relative to the proposed rule. *Id.* at 200-201. As noted previously, DOE is using substantially the same model for the energy efficiency distribution in the no new standards case and Joint Gas Commenters had adequate ability to comment on, and refute, DOE's analyses in the May 2022 CWH ECS NOPR.

Table IV.22 Market Shares for the No-New-Standards Case by Efficiency Level for CWH Equipment

EL	Commercial Gas-fired Storage Water Heaters	Residential-Duty Gas-fired Storage Water Heaters	Gas-fired Instantaneous Tankless Water Heaters	Gas-Fired Circulating Water Heaters and Hot Water Supply Boilers
0	34.3%	53.7%	17.0%	5.3%
1	2.7%	20.9%	0.0%	13.3%
2	0.0%	14.9%	0.0%	12.9%
3	15.3%	3.0%	4.2%	2.1%
4	46.7%	6.0%	20.8%	11.4%
5	1.0%	1.5%	58.1%	55.1%

9. Payback Period Analysis

The PBP 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. PBPs 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[133] 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. Chapter 8 of the final rule TSD provides additional details about the PBP.

10. Embodied Emissions and Recycling Costs

WM Technologies and Patterson-Kelley stated that if the Department utilizes emissions, or reference to carbon in the analysis, then the Department should also acknowledge the cost of embodied carbon in the analysis. Both stakeholders have been working with an ASHRAE group with the intention of improving the general understanding of embodied carbon, LCC, and operational carbon and identifying ways to accurately account for these metrics in HVAC products, among other things. (WM Technologies, No. 25 at pp. 1–2; Patterson-Kelley, No. 26 at pp. 2–3) EPCA requires DOE to consider the total projected energy saving resulting from a standard. DOE considers FFC energy savings, including the energy consumed in electricity production, in distribution and transmission, and in extracting, processing, and transporting primary fuels. DOE does not analyze energy savings (or air pollutant emissions) related to manufacturing, transporting, recycling, or disposing of products, as such impacts would not be considered a direct result of the standard on the energy use of the covered product.

[133] The DOE test procedure for CWH equipment at 10 CFR 431.106 does not specify a calculation method for determining energy use. For the rebuttable presumption PBP calculation, DOE used average energy use estimates.

As such, embodied emission in this process is outside of DOE's CWH ECS rulemaking scope.

Patterson-Kelley and WM Technologies both stated that because the schedule and cost of recycling is different based upon the materials used in the water heater, these differences must be captured in the analysis. The World Green Building Council has recognized that carbon emissions from manufacturing of components, assembly of components into finished goods, their transportation, installation, and the end of life stage must be accounted for as well. (WM Technologies, No. 25 at p. 2; Patterson-Kelley, No. 26 at p. 3) Patterson-Kelley noted that in examining embodied carbon the following must be considered—a higher rate of recycling due to shorter life cycle of condensing products and other changes noted previously. (Patterson-Kelley, No. 26 at p. 3) DOE would note that it has yet to find evidence that condensing equipment has a shorter lifetime than non-condensing equipment, so there would be no change relative to lifetime. DOE takes into account the cost to remove a water heater at the time of replacement. Stakeholders did not provide information concerning the difference in the cost of materials recycling—whether the materials in a condensing water heater have more or less recycling value than a non-condensing water heater. Given that the first replacement of a condensing water heater installed under this standard would be 10 years in the future, DOE believes the discounted present value of any difference would likely be small enough to ultimately be immaterial. DOE has based the installation cost calculations including removal of old water heaters on nationally recognized sources. As a result of these considerations, DOE has not elected to change the analysis to reflect these comments.

11. LCC Model Error Messages and Other

Barton Day Law stated that the LCC spreadsheet model looks almost more like a draft than a final product, and that there are apparently "loads of errors" showing up, including computational errors. (Barton Day Law, Public Meeting Transcript, No. 13 at pp. 32–33) Joint Gas Commenter pointed to error messages in the LCC model, stating there were 11 million cell errors, #N/A, and #DIV/0 errors throughout model; some are labeled blank; others not; some tables and ranges are poorly labeled; and Excel calculations and Visual Basic for Applications, and the large number of worksheets make it more difficult to use and to trace formulas. Joint Gas Commenters stated DOE should correct the errors and give stakeholders sufficient time to review. (Joint Gas Commenters, No. 34 at pp. 36–37)

In response, DOE notes that additional fields were included throughout the LCC model to accommodate additional equipment classes. In the high-level summary sheets where results reported in the NOPR are tabulated, fields related to the additional equipment classes were either removed or contents were erased and labeled as "blank." In some other worksheets, the calculations related to additional product classes were not erased. However, numerous inputs related to potential additional equipment classes were not populated and this fact led to many calculations that attempted division using unpopulated input fields, or in other words, which led to #DIV/0 messages. DOE has removed all of the potential additional product class input fields. In response to the "11 million cell errors," DOE assumes this referred to the fact that the May 2022 CWH ECS NOPR LCC model used a user-defined function, the output of which would turn to an error code and needed to be refreshed when the model was left idle. Refreshing the function required the user to recalculate the model by pressing the F9 key, and once the model was recalculated the error codes would disappear and be replaced by values. To eliminate this source of error messages, DOE eliminated the user defined function by introducing an Excel code in the venting costs worksheet in the block of cells between Q22 and CA82. The new Excel code was written to exactly reproduce the output from the old user defined function, so this modeling change does not affect results but rather it merely removes the irritation of the user defined function timing out and needing to be refreshed. Additionally, in response to the comment that some portions of the model were poorly labeled, DOE added labels to a small number of columns of calculations that DOE considered on review to be inadequately labeled, such as columns at the extreme right edges of the RECS.WH and CBECS.WH worksheets.

A further response to the error messages referred to in the Joint Gas Commenter and Barton Day Law comments – the error messages were cosmetic in the sense that eliminating them did not change any results in the analysis; therefore, there are no new data for Joint Gas Commenters to review strictly in terms of the elimination of these message codes. Based on comments documented in this section of the final rule, DOE believes that Joint Gas Commenters were able to review the LCC model in detailed ways even with the distractions caused by the message codes. Thus, DOE declines to provide additional review time related to the elimination of the extra product class fields.[134]

[134] In response to requests, DOE reopened the comment period on the May 2022 CWH ECS NOPR to provide an additional two weeks for stakeholders to review and provide comments on the NOPR. 87 FR 43226.

Barton Day Law stated DOE should be more transparent about disclosing how the outcomes are allocated in its analysis and what the justification is. (Barton Day Law, Public Meeting Transcript, No. 13 at p. 55) Joint Gas Commenters presented graphs of the cumulative LCC savings of gas-fired tankless consumers from the LCC model, pointing out that the net LCC savings (average) were being generated by a small number of consumers with the largest LCC saving and if such customers were "reassigned" to different baseline efficiencies the result would have been different. (Joint Gas Commenters, No. 34 at p. 27) DOE would note that LCC savings are averages and as such include the results from those with large LCC savings and those with large LCC costs. Because of the way the model works, selecting consumers from the RECS and CBECS datasets for which each equipment type would apply, the number of consumers in the extreme cost and benefit tails will be small. With respect to the Joint Gas Commenter graphic about tankless product LCC results, DOE notes that given the existing distribution, the overwhelming majority of LCC customers modeled experience no impact because they already purchased equipment of the efficiency level selected for the standard. As discussed in section IV.F.8 there are numerous reasons for customers to be either unaware of potential energy savings when they make efficiency decisions or to deliberately ignore such information.

Barton Day Law stated residential-duty gas-fired storage equipment has four different draw patterns and four separate standards but only one LCC analysis. (Barton Day Law, Public Meeting Transcript, No. 13 at pp. 30, 32) Joint Gas Commenters also stated that DOE analyzed four product classes but only provided one LCC analysis and asked that DOE perform an analysis for each class separately, and although the comment was unclear to DOE, it is presumed to refer to the same point Barton Day Law made. (Joint Gas Commenters, No. 34 at pp. 32–33) As noted in IV.C.4.c of this document, all residential-duty gas-fired equipment is within the high draw pattern, so only one analysis was performed of this equipment.

Joint Gas Commenters stated that the rule could have disproportionate impacts on small rural businesses that use propane fired equipment due to their more limited income and therefore a more limited opportunity to fund venting upgrades. They also stated that the problem is made worse by the fact that propane suppliers cannot provide incentives to consumers, as gas utilities can. They also stated that the May 2022 CWH ECS NOPR failed to address impacts on businesses that qualify for the Administration's Justice40 Initiative. They further offered their opinion that DOE's analysis must conform to the National Academy of Science's peer review report and recommendations regarding welfare analysis. Joint Gas Commenters urged DOE to delay the rulemaking while investigating whether the rule would undermine the Justice40 Initiative. (Joint Gas Commenters, No. 34 at pp. 31–32) With respect to the impact on small rural businesses, DOE respects the Joint Gas Commenters note about the more limited income of small rural businesses, but also believes the overall cost structure of small rural businesses includes components that are likely lower than their urban counterparts, such as building lease or ownership costs. DOE also notes that, according to the EIA's AEO used in this final rule, propane is, at a national level, twice as expensive as natural gas on a $/Million Btu basis, meaning that the value of energy savings to these customers would be higher than the value to natural gas customers. Additionally, DOE expects that commercial buildings in rural areas are less likely to reach the 10-story level that is cited by various commenters as problematic in vent installations. DOE also expects that commercial buildings in rural areas are less likely to share common brick walls with other neighboring businesses or have issues venting over sidewalks or busy alleys. This means rural businesses may find it easier to use horizontal venting than their metropolitan counterparts. While this advantage could be offset at least partially by a greater chance of having to deal with snow levels when siting a horizontal vent, DOE disagrees with the bottom line conclusion of this comment. With respect to the National Academy of Sciences report, the recommendations in the report, which pertain to the processes by which DOE analyzes energy conservation standards, are being considered in a separate rulemaking considering all product categories and DOE does not believe that this final rule should be delayed while the National Academy of Sciences report is considered.

WM Technologies stated they received an error trying to run the LCC model. They noted a macro returned an error message stating "Compile Error: Can't find project or library" with the "VBA Code Subroutine cmdRun_Click() references [ControlPanel.IncomeBins]" highlighted. (WM Technologies, No. 25 at p. 10) DOE tested the LCC model to attempt to reproduce this error code, and the only way DOE could generate this code was to load the LCC model onto a computer that did not have Crystal Ball installed on it. Without Crystal Ball being installed, the macro is searching for software package references that do not exist. DOE has added language in appendix 8A of the final rule TSD describing how/why having Crystal Ball installed on the computer is necessary for reviewing this LCC model.

WM Technologies recommended the Department move the instructions for operating LCC models to the beginning of the TSD or provide a note there referencing the instruction location. (WM Technologies, No. 25 at p. 10) They additionally request a frequently asked questions website is made available to support industry review of the LCCs along with a question and answer portion where industry could post questions. (WM Technologies, No. 25 at p. 10) DOE notes that the May 2022 CWH ECS NOPR TSD chapter 1 included an outline of the document, and pointed to appendix 8A, which provides instructions. DOE additionally encourages stakeholders to utilize the public meetings to ask questions related to operation of the LCC and other models, and will consider whether more general resources are warranted.

WM Technologies commented that after running the analysis on a local computer and using the Forecast Report writer in Crystal Ball, several cells identified cell errors and yet the analysis continued and provided results. WM Technologies noted some values of forecasts cells were empty. WM Technologies requested the Department provide further commentary on why empty values are present in forecast reports, particularly when the all product categories are subject to 10,000 iterations. (WM Technologies, No. 25 at p. 10) In response, DOE notes that the LCC model at each iteration selects a baseline efficiency for use in the iteration for all four equipment classes. For any possible efficiency level other than the lowest level, this leads to a situation where, by definition, there will be no LCC savings if a standard is set at that level. For example, if the model selects EL3 as the baseline, there would be no LCC savings and no PBP results for a standard set at lower efficiency levels. Because the number 0 is a valid result, setting those to 0 introduces possible issues. Rather, the model sets them equal to a blank, or a character field set to " ". Thus if you print the forecast report, you will find blanks. Because introducing characters into downstream calculations causes math errors, the Crystal Ball routines are instructed by the VBA code to ignore these errors. DOE has used this method in LCC models for years to distinguish between "no impact cases" and cases with a valid result of 0.

WM Technologies requested the Department comment upon how different geographic areas are referenced in the same iteration. (WM Technologies, No. 25 at p. 10) At each iteration, the LCC model pulls eight samples, a RECS and CBECS sample for each of the four equipment classes, and then selects either residential or commercial to choose whether to use the RECS or CBECS sample. Those eight samples will all have their own geographic location linked to either the RECS or the CBECS samples selected, and would only purely by chance have the same geographic location.

WM Technologies stated their review of chapter 8 and appendix 8G did not clearly identify how the subgroup analysis is completed. They said further review of the LCC workbook indicates that the low-income subgroup is comprised of the first six bins in cells O3 to P28, and shown in B6 to B11. However, the assumption cell (B40) makes a probabilistic selection from range B6 to B36. Specifically, they stated it would be beneficial to only run the sub-group analysis by hard coding the selection of income bins. They asked DOE to please verify that the correct values to hard code are in the range of B15 to AS16 on the "Bldg.Sample" tab. Additionally, they asked DOE to please provide insight into and how cells FG4 to FG12086 in tab "RECS.WH" relate the analysis and how the range D30 to E 54 on the "Control.Panel" tab interact with the analysis. (WM

Technologies, No. 25 at p. 10) In response, DOE notes that the entire column of B6 to B36 comprises the probability distribution for the lowest 20 percent of residential households, or, in other words, the households that would be included in the low-income subgroup. The six bins that are referred to in cells O3 through P28 refer to the effort to remap the RECS income bins to the discount rate bins. The discount rates break the entire residential sector out by percentage of households while RECS breaks households out into discrete income bins. The model codes individual RECS samples as either eligible for the sub-group using the look-up table referenced above on the Control Panel tab and column CC on the Sampling Distributions. Column CC is either 0 or 1. If the model is not running a subgroup, all RECS income bins are coded as 1. If the model is running a subgroup, only those RECS income bins in the subgroup are coded 1, and the rest are coded 0. On the Sampling Distribution tab, the sampling weight assigned to each RECS observation is multiplied by the corresponding row of column CC. Thus, in a regular run, all households could be chosen. In a subgroup model run, only those households in the 0–20 percent of household income could be chosen.

G. Shipments Analysis

DOE uses projections of annual equipment shipments to calculate the national impacts of potential amended or new energy conservation standards on energy use, NPV, and future manufacturer cash flows.[135] The shipments model, discussed in section IV.G.6 of this final rule, takes an accounting approach, tracking market shares of each equipment category and the vintage of units in the stock. Stock accounting uses equipment

[135] 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.

shipments as inputs to estimate the age distribution of in-service equipment stocks for all years. The age distribution of in-service equipment 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.

1. Commercial Gas Fired and Electric Storage Water Heaters

To develop the shipments model, DOE started with known information on shipments of commercial electric and gas-fired storage water heaters collected for the years 1994–2022 from the AHRI website,[136] and extended back to 1989 with data contained in a DOE rulemaking document published in 2000.[137] The historical shipments of commercial electric and gas-fired storage water heaters are summarized in Table IV.23 of this final rule. Given that the estimated average useful lifetimes of these two types of equipment are 12 and 10 years, respectively, the historical shipments provided a basis for the development of a multi-year series of stock values. Using the stock values, a saturation rate was determined by dividing equipment stock by building stock, and this saturation rate was combined with annual building stock additions to estimate the shipments to new construction. With these data elements, a yearly accounting model was developed for the historical period to identify shipments deriving from new construction and from replacements of existing equipment. The accounting model also identified consumer migration into or out of the storage water heater equipment classes by

[136] Air Conditioning, Heating, and Refrigeration Institute. Commercial Storage Water Heaters Historical Data and Monthly Shipments. Available at *www.ahrinet.org/analytics/research/historical-data/commercial-storage-water-heaters-historical-data* and *www.ahrinet.org/analytics/statistics/monthly-shipments*. Last accessed March 10, 2023.
[137] U.S. Department of Energy. Screening Analysis for EPACT-Covered Commercial HVAC and Water-Heating Equipment. Volume 1 – Main Report. 2000. EERE-2006-STD-0098-0015. Available at *www.regulations.gov/#!documentDetail;D=EERE-2006-STD-0098-0015*.

calculating the difference between new plus replacement shipments and the actual historical shipments.

Table IV.23 Historical Shipments of Commercial Gas-Fired and Electric Storage Water Heaters

Year	Commercial Gas-Fired Storage	Commercial Electric Storage
1994	91,027	22,288
1995	96,913	23,905
1996	127,978	26,954
1997	96,501	30,339
1998	94,577	35,586
1999	100,701	39,845
2000	99,317	44,162
2001	93,969	46,508
2002	96,582	45,819
2003	90,292	48,137
2004	96,481	57,944
2005	82,521	56,178
2006	84,653	63,170
2007	90,345	67,985
2008	88,265	68,686
2009	75,487	55,625
2010	78,614	58,349
2011	84,705	60,257
2012	80,490	67,265
2013	88,539	69,160
2014	94,247	73,458
2015	98,095	88,251
2016	97,026	127,344
2017	93,677	152,330
2018	94,473	137,937
2019	88,548	150,667
2020	80,070	140,666
2021	90,192	154,330
2022	83,487	120,152

For the May 2022 CWH ECS NOPR, DOE utilized regression techniques to develop the shipments forecast based on the assumption that shipments of gas-fired storage water heaters are a function of relative prices of natural gas and electricity, building stocks (*i.e.*, the replacement market), and building stock additions (the new market); the regression inputs were updated with 2022 data for this final rule. The result was a model yielding a forecast of shipments that increases 0.03 percent per year from 2023–2055, reaching just over 90,100 units by 2055. See chapter 9 of the final rule TSD for further details. The resulting growth rate for shipments is less than the underlying growth in building stocks (0.9 percent between 2023–2055).

For the May 2022 CWH ECS NOPR and for this final rule, no historical information was available that specifically identified shipments of gas-fired storage-type instantaneous water heaters. The AHRI online historical shipments data explicitly states residentially marketed equipment is excluded but does not explicitly state whether instantaneous storage equipment is included or excluded. Because of the similarities between the commercial storage gas water heaters and the gas-fired storage-type instantaneous water heaters, DOE has included both in downstream analyses in this final rule. However, DOE recognizes that some or all of the storage-type instantaneous shipments may not be captured in the historical AHRI shipments data. The DOE shipments analysis is derived from AHRI historical shipments data and thus may underrepresent future shipments of gas-fired storage-type instantaneous water heaters.

2. Residential-Duty-Gas-Fired Storage and Instantaneous Water Heaters

For the May 2022 CWH ECS NOPR, DOE developed an econometric model similar to that described for commercial gas-fired storage water heater shipments. Following publication of the withdrawn May 2016 CWH ECS NOPR, AHRI provided data from manufacturers on instantaneous water heater shipments to DOE's contractors under a confidentiality agreement and indicated that the data include shipments of gas-fired instantaneous tankless and circulating water heating equipment. DOE used these data to estimate an equation relating commercial instantaneous shipments to building stock additions and commercial electricity prices.[138] Because the historical data did not provide sufficient detail to identify the percentages represented by tankless and circulating water heater shipments, DOE estimated that 50 percent of the shipments are instantaneous tankless shipments and the remainder are circulating water heaters. Because the actual information provided by AHRI is confidential and cannot be disclosed, the only information being made available in this final rule is the econometric forecast made for use in the analysis.

Since the equipment that DOE has been calling hot water supply boilers includes what AHRI calls circulators as well as a second type of equipment AHRI calls boilers, DOE clarifies that the new DOE forecast for hot water supply boilers includes both circulating water heating equipment and hot water supply boilers. The circulating water heater shipments were developed as described earlier. In the May 2022 CWH ECS NOPR, DOE requested additional historical shipment information for commercial gas-fired instantaneous tankless water heaters to supplement the data provided in response to the withdrawn May 2016 CWH ECS NOPR, and also sought actual historical shipments for gas-fired storage-type instantaneous water heaters and hot water supply boilers, but

[138] While the instantaneous units are gas-fired, natural gas variables consistently exhibited incorrect signs on the estimated coefficients. For example, the ratio of commercial electric price divided by commercial gas had a negative sign, meaning that higher ratios would lead to lower shipments. This is the opposite of what was expected. Higher electric prices relative to gas prices should lead to higher, not lower, shipments of the natural gas products. Thus, commercial natural gas price variables were omitted from the model.

did not receive any data, and DOE was not able to identify additional information sources for the instantaneous equipment class shipments.

In the May 2022 CWH ECS NOPR, DOE requested actual historical shipment data for residential-duty gas-fired storage water heaters, but did not receive any data, and DOE was not able to identify additional information sources for residential-duty gas-fired shipments. DOE clarifies that residential-duty gas-fired storage water heaters are not residential water heaters. Instead, they are a type of CWH equipment and DOE draws no conclusions about residential-duty gas-fired storage shipments replacing or being replaced by commercial gas-fired storage water heater shipments. Rather, the linkage used in the DOE model would essentially have shipments of both types of storage equipment going up or down in parallel. DOE retained the forecasting method used for the May 2022 CWH ECS NOPR, using the same 20 percent factor. In other words, DOE assumes residential-duty gas-fired storage water heater shipments track with commercial gas-fired storage water heaters, and shipments of the former are assumed to be 20 percent of the shipments of the latter.

3. Available Products Database and Equipment Efficiency Trends

For the May 2022 CWH ECS NOPR, DOE revised the shipments and other analyses to reflect efficiency distribution data for commercial gas-fired storage water heaters and instantaneous gas-fired water heaters provided by AHRI, reconciling the analyses to account for the AHRI data rather than relying heavily on the number of available models to produce equipment efficiency trends. For this final rule analysis, DOE used the same adjustment method to account for underlying growth in high-efficiency products.

In the May 2022 CWH ECS NOPR, DOE requested historical shipments data dividing shipments between condensing and non-condensing efficiencies for all equipment types that comprise the subject of this proposed rulemaking. In comments filed in response to the May 2022 CWH ECS NOPR, A.O. Smith stated that the percentage of commercial gas-fired instantaneous circulating water heaters and hot water supply boilers shipments that are condensing is lower than the percentage for gas storage products. (A.O. Smith, No. 22 at p. 3) As discussed in section IV.H.1, DOE used the AHRI-provided historical data received following the withdrawn May 2016 CWH ECS NOPR to fit a Bass Diffusion curve for each of the equipment categories analyzed for this final rule. With respect to the concern raised by A.O. Smith regarding condensing shares of circulating water heaters and hot water supply boilers in comparison to commercial gas storage water heaters, the data received from AHRI regarding the fraction of the units of the instantaneous equipment class that were condensing at 90 percent and over was higher than it was for the commercial gas storage category, and DOE did not receive any additional data nor identify additional sources of shipments by efficiency level for the instantaneous equipment categories on which DOE could base an adjustment to the diffusion curve. Further, DOE reviewed the underlying model counts and notes that the unadjusted model counts for condensing level commercial gas-fired storage and condensing level instantaneous circulating water heaters and hot water supply boilers are the same percentage of total models (45 percent). While DOE appreciates A.O. Smith's comment, the most recent industry data supplied by AHRI does not indicate that the condensing share of instantaneous circulating water heaters and hot water supply boilers are less than those for the commercial gas-fired storage equipment class.

In comments filed in response to the May 2022 CWH ECS NOPR, Rheem noted that the same colors were used for "Com/Res-Duty Gas Storage" and "Gas Instant HWSB" in Figure 10.2.1 of the NOPR TSD making it difficult to comment; however, Rheem commented it appeared that DOE was estimating between 55 and 60 percent of gas-fired storage water heaters are condensing, and that the breakdown between non-condensing and condensing levels needs review; Rheem also noted that they were willing to discuss the breakdown in a confidential meeting. (Rheem, No. 24 at p. 3, 6)

DOE thanks Rheem for pointing out that the colors used in Figure 10.2.1 of the May 2022 CWH ECS NOPR TSD were difficult to differentiate, and DOE has made adjustments to that figure within the final rule TSD to better distinguish the data illustrated there. Regarding Rheem's concern about condensing versus non-condensing shares of commercial gas-fired storage water heaters, DOE notes that the most recent ENERGY STAR data for commercial gas-fired water heaters reports an estimated market penetration of 49 percent of total commercial gas-fired water heaters were ENERGY STAR qualified in 2021, with a thermal efficiency greater than or equal to 0.94.[139] DOE notes that there are additional condensing models currently on the market that do not meet ENERGY STAR requirements, so the total estimated condensing percentage is

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[139] U.S. EPA. ENERGY STAR Unit Shipment and Market Penetration Report Calendar Year 2021 Summary. Available at *www.energystar.gov/sites/default/files/asset/document/2021%20Unit%20Shipment%20Data%20Summary%20Report_0.pdf*. Last accessed December 17, 2022.

likely higher than ENERGY STAR levels. As discussed in response to the A.O. Smith comment earlier, AHRI supplied industry-level data on condensing shares of commercial gas-fired storage water heaters that has been fit to a Bass Diffusion curve, and the additional information received during supplemental manufacturer interviews did not include additional data on which to base changes to these percentages.

In comments filed in response to the May 2022 CWH ECS NOPR, A.O. Smith also stated that an analysis of their own shipments shows that 5 percent of residential-duty gas-fired storage units are condensing. (A.O. Smith, No. 22 at p. 4) In the May 2022 CWH ECS NOPR, DOE had used the same condensing market share curve calculated for commercial gas-fired storage water heaters, projected to be greater than 60 percent by 2026. In response, DOE considered the A.O. Smith data point, recognizing that it is a single data point that may not be representative of the entire industry, and also reviewed both ENERGY STAR data and the model counts database. Residential-duty gas-fired storage water heaters are included under the residential ENERGY STAR water heater program, rather than the commercial gas water heater program. Based on ENERGY STAR data, shipments of ENERGY STAR-rated residential gas-fired water heaters as a share of total shipments was 8 percent in 2021.[140] DOE notes that historically, not all ENERGY STAR-rated residential gas-fired water heaters have been condensing models,[141] and also that the estimated number of residential-duty gas-fired

[140] U.S. EPA. ENERGY STAR Unit Shipment and Market Penetration Report Calendar Year 2021 Summary. Available at *www.energystar.gov/sites/default/files/asset/document/2021%20Unit%20Shipment%20Data%20Summary%20Report_0.pdf*. Last accessed December 17, 2022.

[141] ENERGY STAR updated its residential gas water heater criteria, including its criteria for gas-fired storage residential-duty commercial water heaters, effective on April 18, 2023. Under the updated

water heaters are a small fraction of total residential gas-fired water heater shipments, so DOE was not able to definitively determine what share of the residential-duty market is comprised of condensing equipment. DOE calculated that the percentage of residential-duty gas-fired water heaters that are condensing according to model counts is 32 percent, which is significantly less than the 45 percent of model counts identified as condensing for commercial gas-fired storage water heaters. For this final rule, DOE has revised the condensing market share for residential-duty gas-fired storage water heaters based on this information, using the historical ENERGY STAR residential water heater shipments to fit the Bass Diffusion curve. As conveyed in section IV.H.1, the overall resulting condensing share diffusion curve for the residential-duty equipment class is now lower than that modeled for commercial gas-fired storage water heaters.

A.O. Smith raised concerns that setting new minimum energy conservation standards for commercial gas-fired products at 95 percent and 96 percent thermal efficiency will have a dilutive effect on the ENERGY STAR program. For ENERGY STAR to remain a relevant catalyst for market adoption of commercial gas-fired water heaters, A.O. Smith said ENERGY STAR would need to set a new specification level significantly above the Department's proposed new minimums, which de facto would render the program obsolete for gas-fired CWH. A.O. Smith believes such an outcome would create significant marketplace competition implications considering technology feasibility, manufacturer product costs (MPCs) as well as limit product options for commercial businesses. (A.O. Smith, No. 22 at p. 3) Similarly, Atmos Energy stated that

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specification requirements, residential-duty gas-fired storage water heaters would likely need to be condensing to be ENERGY STAR compliant.

the proposed standards would negatively impact existing rebate programs. Atmos Energy stated that incentive programs provide a cost-effective means for improving residential building energy efficiency without requiring a market transition through which the water heating options consumers need are no longer available. (Atmos Energy, No. 36 at p. 3)

As discussed in section IV.C.4.a, DOE reviewed the efficiency level distributions of products on the market and found that the market distributions show the greatest number of unique basic models within the condensing range at 96 percent for gas-fired storage water heaters and storage type-instantaneous water heaters, gas-fired tankless water heaters, and gas-fired circulating water heaters and hot water supply boilers. DOE anticipates that there is still room for product differentiation, particularly for gas-fired storage water heaters which account for most of the shipments in this final rule, where products above 95 percent efficiency currently exist at 96, 97, 98, and 99 percent, and DOE also notes that products exist at 97 percent efficiency for tankless water heaters, and that there are products at 97, 98, and 99 percent efficiency products for circulating water heaters and hot water supply boilers. Thus, ENERGY STAR specifications could be updated, allowing for the continuation of utility rebate and other incentive programs.

4. Electrification Trends

In comments submitted in response to the May 2022 CWH ECS NOPR, several stakeholders expressed concerns about the impact of legislation and codes requiring electrification. Bradford White believes that local policies and codes that restrict the use of gas-fired commercial water heaters need to be taken into account, and both WM Technologies and Patterson-Kelley noted that local building codes are limiting installation of new gas-fired products, which are a risk of decreased future annual shipments across the market, and that changes in building codes related to discarding appliances prior to the end of their normal operational life could also impact shipments. (Bradford White, No. 23 at p. 6; WM Technologies, No. 25 at p. 3; Patterson-Kelley, No. 26 at p. 3) WM Technologies also commented that changes in building codes relating to electrification are impacting fuel switching differently at different efficiency levels in some localities. (WM Technologies, No. 25 at p. 3) AHRI also noted building code changes in states like Washington that are requiring heat pump water heating. (AHRI, No. 31 at p. 6) In response, DOE has conducted an internet search of State and municipal level legislation and building codes to identify locations where electrification requirements have been put into place, and where building codes have been changed with respect to discarding appliances prior to the end of their normal life. DOE identified a total of 81 municipalities and 1 state with an electrification requirement, either for new buildings, or upon equipment replacement.[142] DOE also identified a total of 20 States that have prohibited building gas restrictions and electrification mandates.[143] DOE was not able to identify any building codes that had been changed with respect to discarding appliances prior to the end of their normal life. DOE further notes that States and municipalities are actively proposing plans or legislation addressing electrification, or prohibiting electrification. Until these are adopted or passed, they are subject to change. As such, DOE attempted to account only for those jurisdictions that have passed or

[142] Building Decarbonization Coalition, Zero Emission Building Ordinances, State and Local Government Decarbonization Efforts. Available at *buildingdecarb.org/zeb-ordinances.html*, Last accessed November 28, 2022.

[143] Gas Ban Monitor: East Coast policies advance; Pa. gas ban prohibition fails, August 2, 2022. Available at www.spglobal.com/marketintelligence/en/news-insights/latest-news-headlines/gas-ban-monitor-east-coast-policies-advance-pa-gas-ban-prohibition-fails-71439034. Last Accessed November 28, 2022.

adopted electrification requirements. For example, both California and New York have released plans that incorporate end-use electrification for buildings, but neither State has finalized those plans.[144, 145] Thus only municipalities within these States that have passed or adopted electricity requirements were included in DOE's analysis. DOE conducted a sensitivity analysis of potential electrification trends to consider the impact of additional electrification if both California and New York were to adopt electrification requirements state-wide (see appendix 10B of the final rule TSD).

Additionally, DOE notes that in December of 2022, DOE published the Clean Energy for New Federal Buildings and Major Renovations of Federal Buildings SNOPR ("Clean Energy Rule") as required by section 433 of the Energy Independence and Security Act of 2007 ("EISA 2007"), which requires that fossil fuel generated energy consumption be reduced to zero (as compared to a 2003 baseline) by 2030 for new construction and major renovations of Federal buildings.[146] Federal buildings are also subject to E.O. 14057, which requires that all new construction and major modernization projects greater than 25,000 gross square feet be designed, constructed, and operated to be net-zero emissions by 2030, and that the Federal sector will have a net-zero emissions

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[144] California Air Resources Board, November 16, 2022. 2022 Scoping Plan for Achieving Carbon Neutrality. Available at *ww2.arb.ca.gov/sites/default/files/2022-11/2022-sp.pdf*. Last accessed December 19, 2022.
[145] New York State Climate Action Council. 2022. "New York State Climate Action Council Scoping Plan." Available at *climate.ny.gov/-/media/project/climate/files/2022-12-15-Draft-Final-Scoping-Plan.pdf*. Last accessed December 20, 2022.
[146] Available at www.federalregister.gov/documents/2022/12/21/2022-27098/clean-energy-for-new-federal-buildings-and-major-renovations-of-federal-buildings. Last accessed February 13, 2023.

building portfolio by 2045, including a 50 percent emissions reduction (over 2008 levels) by 2032.[147]

DOE used this information to develop an adjustment to account for reduced shipments due to electrification requirements. In total, based on policies and codes that have been adopted as of November 28, 2022, approximately 8 percent of the United States by population will be subject to electrification requirements for new buildings by 2026, with approximately 0.3 percent subject to electrification upon equipment replacement. Additionally, based on the proposed Clean Energy Rule and E.O. 14057, the potential percentage of floorspace impacted by Federal rules and requirements would range from 0.6 percent to 0.9 percent of new construction, and of 0.6 percent to 2.3 percent of replacements. The resulting adjustments are shown in Table IV.24.

[147] E.O. 14057: Catalyzing Clean Energy Industries and Jobs Through Federal Sustainability, December 8, 2021. Available at *www.fedcenter.gov/programs/eo14057/*. Last accessed December 16, 2022.

Table IV.24 Electrification Reductions

Year	New Shipment Reductions	Replacement Shipment Reductions
2026	8.6%	0.9%
2027	8.6%	1.0%
2028	8.6%	1.1%
2029	8.5%	1.3%
2030	8.5%	1.4%
2031	8.5%	1.5%
2032	8.6%	1.6%
2033	8.6%	1.7%
2034	8.6%	1.8%
2035	8.7%	1.9%
2036	8.7%	1.9%
2037	8.7%	2.0%
2038	8.8%	2.1%
2039	8.8%	2.2%
2040	8.8%	2.3%
2041	8.8%	2.3%
2042	8.9%	2.4%
2043	8.9%	2.5%
2044	8.9%	2.6%
2045	8.9%	2.6%
2046	8.9%	2.6%
2047	8.9%	2.6%
2048	8.9%	2.6%
2049	8.8%	2.5%
2050	8.8%	2.5%
2051	8.8%	2.5%
2052	8.8%	2.5%
2053	8.8%	2.5%
2054	8.8%	2.5%
2055	8.8%	2.4%

A more detailed discussion of this adjustment and the underlying calculations is contained in chapter 9 of this TSD.

5. Shipments to Residential Consumers

DOE determined the fractions of commercial and residential applications for each equipment category based on the number of samples (in both CBECS and RECS) selected as relevant to be served by each equipment category considered in this rulemaking. Based on comments received in response to the withdrawn May 2016 CWH ECS NOPR, DOE included only residential multi-family stocks and building additions when considering the potential non-commercial consumer component in the development of the shipments forecast in the May 2022 CWH ECS NOPR. In comments received on the May 2022 CWH ECS NOPR, Bradford White noted DOE has overstated the amount of commercial gas-fired storage and storage-type instantaneous water heaters that are installed in residential applications, as in their experience, there are very few residential installations where this occurs (*e.g.*, typically high end, large homes), and that they do not see gas-fired circulating water heaters and hot water supply boilers used in residential applications. (Bradford White, No. 23 at p. 6) DOE wishes to clarify that the only residential applications considered in both the May 2022 CWH ECS NOPR and this final rule analysis are those in multi-family buildings; single family and manufactured home applications were excluded from the analysis, as previously suggested by commenters in response to the withdrawn May 2016 CWH ECS NOPR.

6. Final Rule Shipment Model

To project shipments and equipment stocks for 2023 through the end of the 30-year analysis period (2055), DOE used the shipments forecasting models (described in sections IV.G.1 and IV.G.2 of this final rule), a stock accounting model, and adjustments for electrification. The stock accounting model keeps track of shipments and calculates replacement shipments based on the historical shipments, the expected useful lifetime of each equipment class, and a Weibull distribution that identifies a percentage of units still in existence from a prior year that will fail and need to be replaced in the current year. In each year, DOE assumed a fraction of the replacement market will be retired rather than replaced due to the demolition of buildings in which this CWH equipment resides. This retirement fraction was derived from building stock data from the *AEO2023*.[148]

To project shipments of CWH equipment for new construction, DOE relied on building stock data obtained from *AEO2023*. For this final rule, DOE assumes CWH equipment is used in both commercial buildings and residential multi-family buildings. DOE estimated a saturation rate for each equipment type using building and equipment stock values. The saturation rate was applied to new building additions in each year, yielding shipments to new buildings. The building stock and additions projections from *AEO2023* are shown in Table IV.25.

Table IV.25 Building Stock Projections

Year	Total Commercial Building Stock *million sq. ft.*	Commercial Building Stock Additions million sq. ft.	Multi-Family Residential Building Stock *millions of units*	Multi-Family Residential Building Additions *millions of units*
2022	93,444	2,027	32.84	0.61
2025	96,234	2,272	33.86	0.49
2026	97,373	2,197	34.18	0.49
2030	101,747	2,473	35.47	0.49
2035	108,065	2,336	36.93	0.46
2040	112,879	2,127	38.37	0.48
2045	116,845	2,152	39.78	0.47
2050	121,045	2,293	41.14	0.48
2055*	123,348	2,381	42.61	0.51

Source: EIA *AEO2023 Reference case.*

148 U.S. Energy Information Administration (EIA). *2023 Annual Energy Outlook.* March 2023. Available at *www.eia.gov/outlooks/aeo/*.

Year	Total Commercial Building Stock *million sq. ft.*	Commercial Building Stock Additions million sq. ft.	Multi-Family Residential Building Stock *millions of units*	Multi-Family Residential Building Additions *millions of units*

* Post-2050, the projections were extended using the average annual growth rate from 2040 to 2050.

The next component in the stock accounting model is the calculation of shifts to or away from particular equipment classes. For this final rule, shipments were an input to the stock model. For both the historical and forecasted period, shifts to or away from a particular equipment class were calculated as a remainder. Using a saturation rate derived from historical equipment and building stocks, the model estimates shipments to new buildings. Using historical stock and retirement rates based on equipment life, the model estimates shipments for stock replacement. Shifts to or away from a particular equipment class equal the total shipments less shipments for new buildings and shipments for replacements. While DOE refers to the remainders as "shifts to or away from the equipment class," the remainders could be a result of numerous factors: equipment lasting longer, which reduces the number of replacements; increased or decreased need for hot water generally due to greater efficiency in water usage; changing patterns of commercial activity; outside influences, such as ENERGY STAR and utility conservation or marketing programs; actual shifts between equipment classes caused by relative fuel prices, relative equipment costs and efficiencies, installation costs, repair and maintenance costs, and consumer preferences; and other factors.

Based on the historic data, there is an apparent shift toward electric storage water heating equipment. The historical shipments summarized in Table IV.23 of this document show a steady growth in commercial electric storage water heaters, with shipments growing from 22,288 in 1994 to 154,330 in 2021, but declining in 2022 to 120,152, the lowest since 2016. Over the same time period, commercial gas-fired storage water heaters have seen a decline in shipments from 91,027 in 1994 to a low of 75,487 in 2009. After 2009, gas-fired storage water heater shipments rebounded, reaching a shipment level of 90,192 in 2021 (and a peak of 98,095 in 2015), although they declined again in 2022, to 83,487, the second lowest year since 2013. During the period 2009 through 2015, there was a reduction in the apparent shift away from commercial gas-fired storage units compared to the earlier period; however, there appeared to be an increase in 2016–2017 before returning to a reduction in the shift in commercial gas-fired storage units. Because the forecasted shipments of residential-duty gas-fired storage water heaters are linked to commercial gas-fired storage units, there is a similar shift away from the residential-duty gas-fired storage equipment class in the shipment forecast. Gas-fired instantaneous equipment appears to have a positive shift pattern.

Because the commercial gas-fired storage and gas-fired instantaneous CWH shipments forecasts were developed using econometric models based on historical data, these apparent shifts are captured in DOE's shipments model and embedded in the total forecast. For purposes of assigning equipment costs and energy usage in the NIA, DOE needs to know if the increased/decreased shipments are new or replacement shipments. For all equipment classes, DOE assumed that the apparent shift is most likely to occur in new installations rather than in the replacement installations. As described in chapter 9 of the final rule TSD, DOE assumed that a shift is twice as likely to take place in a new installation as in a replacement installation. For example, if DOE estimated that in 2023, 20 percent of shipments for an equipment class went to new installations and 80 percent went for replacements in the absence of switching, DOE multiplied the 20 percent by 2 (40 percent) and added the 80 percent (which equals 120 percent). Both the 40 percent for new and the 80 percent for replacement were then divided by 120 percent to normalize to 100 percent, yielding revised shipment allocations of 33 percent for new and 67 percent for replacement.

Finally, an adjustment is made to account for units projected to switch out of the equipment class due to electrification requirements. The estimated percent reduction shown in Table IV.24 is applied to the new and replacement shipments calculated for each year as described previously. These modified shipments are then accounted for in future stock retirements so that once a unit has "exited" the stock, it does not re-enter when it would be due for replacement.

The resulting shipment projection is shown in Table IV.26.

Table IV.26 Shipments of Commercial Water Heating Equipment

Year	Commercial Gas-fired Storage Water Heaters and Gas-fired Storage-type Instantaneous Water Heaters Units*	Residential-duty Gas-fired Storage Water Heaters units	Gas-fired Tankless Water Heaters units	Gas-fired Circulating Water Heaters and Hot Water Supply Boilers units
2023	87,890	17,548	9,612	11,141
2025	89,827	17,919	10,123	11,658
2026	90,483	18,051	10,312	11,931
2030	90,838	18,189	13,212	15,123
2035	89,229	17,839	14,970	17,076
2040	88,121	17,617	16,700	18,615
2045	87,733	17,545	18,822	20,726
2050	87,422	17,484	21,013	22,992
2055	86,917	17,380	23,259	25,366

* The projected shipments are based on historical data for commercial gas-fired storage water heaters which may or may not include storage-type instantaneous shipments. For analysis purposes, DOE has grouped these categories but recognizes that future shipments for storage-type instantaneous may not be captured in the projection.

Because the estimated energy usage of CWH equipment differs by commercial and residential settings, the NIA employs the same fractions of shipments (or sales) to commercial and to residential consumers used by the LCC analysis. The fractions of shipments by type of consumer are shown in Table IV.27.

Table IV.27 Shipment Shares by Type of Consumer

Equipment		Commercial	Residential
Commercial gas-fired storage water heaters and gas-fired storage-type instantaneous water heaters		84%	16%
Residential-duty gas-fired storage water heaters		60%	40%
Gas-fired instantaneous water heaters and hot water supply boilers	Gas-fired tankless water heaters	60%	40%
	Gas-fired circulating water heaters and hot water supply boilers	85%	15%

For the NIA model, shipments must be disaggregated by efficiency levels that correspond to the levels analyzed in the engineering and LCC analyses. To identify the percentage of shipments corresponding to each efficiency level, DOE combined the efficiency trends based on AHRI and manufacturer shipments data and information derived from a database of equipment currently produced and sold by manufacturers. The sources of information for this database included the DOE Compliance Certification and manufacturer catalogs and websites. DOE used the AHRI shipments data provided in response to the withdrawn May 2016 CWH ECS NOPR to project the percentage of shipments that are condensing and non-condensing, for the period from 2015 through the end of the analysis period. Starting with the last year of historical data from AHRI, shipments within the non-condensing and condensing efficiency ranges were distributed based on the available models database. Because the efficiency bins used in the AHRI shipments data did not exactly match the thermal efficiency bins studied by DOE, available models were used to re-distribute the historical shipment period within the non-condensing and condensing efficiency ranges to match the DOE thermal efficiency levels. For each subsequent year in the final rule analysis period, as the percentage of shipments that are in the condensing efficiency range increases, the shipments are distributed across the condensing thermal efficiency levels by increasing proportionally the percentage of shipments by efficiency level in the previous year. Similarly, as the percentage of non-condensing shipments decrease, DOE distributed shipments across thermal efficiency levels by proportionately decreasing the percentage of shipments in the prior year.

H. National Impact Analysis

The NIA assesses the 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.[149] ("Consumer" in this context refers to consumers of the equipment being regulated.) DOE calculates the NES and NPV for the potential standard levels considered based on projections of annual equipment shipments, along with the annual energy consumption and total installed cost data from the energy use and LCC analyses. For the present analysis, DOE projected the energy savings, operating cost savings, equipment costs, and NPV of consumer benefits for equipment shipped from 2026 through 2055, the year in which the last standards-compliant equipment would be shipped during the 30-year analysis period.

[149] The NIA accounts for impacts in the 50 states and U.S. territories.

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 equipment 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 equipment 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 equipment 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. Chapter 10 and appendix 10A of the final rule TSD explain the model and how to use it. The model and documentation are available on DOE's website.[150] 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.

Unlike the LCC analysis, the NIA does not use distributions for inputs or outputs, but relies on inputs based on national average equipment costs and energy costs. DOE used the NIA spreadsheet to perform calculations of NES and NPV using the annual energy consumption, maintenance and repair costs, and total installed cost data from the

[150] DOE's webpage on CWH equipment is available at www1.eere.energy.gov/buildings/appliance_standards/standards.aspx?productid=36.

LCC analysis. The NIA also uses energy prices and building stock and additions consistent with the projections from the *AEO2023*. NIA results are presented in chapter 10 of the final rule TSD.

Table IV.28 summarizes the inputs and methods DOE used for the NIA analysis for this final rule. Discussion of these inputs and methods follows the table. See chapter 10 of the final rule TSD for further details.

Table IV.28 Summary of Inputs and Methods for the National Impact Analysis

Inputs	Method
Shipments	Annual shipments from shipments model.
Compliance Date of Standard	2026
Efficiency Trends	No-new-standards case, 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.
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	3 percent and 7 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. DOE uses a no-new-standards-case distribution of efficiency levels to project what the CWH equipment market would look like in the absence of potential standards. For the withdrawn May 2016 CWH ECS NOPR, DOE developed the no-new-standards-case distribution of equipment by thermal efficiency levels, and by standby loss efficiency levels, for CWH equipment by analyzing a database[151] of equipment currently available. 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 (2026). In this scenario, the market shares of equipment 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 equipment above the standard would remain unchanged. The approach is further described in chapter 10 of the final rule TSD.

For this final rule, DOE developed the no-new-standards distribution of equipment by thermal efficiency levels for CWH equipment using data from DOE's Compliance Certification database, data submitted by AHRI regarding condensing versus non-condensing equipment, and ENERGY STAR shipments for residential gas-fired water heaters. Using the data provided by AHRI for commercial gas-fired storage water heaters and instantaneous gas-fired water heaters and hot water supply boilers, DOE has modeled a no-new-standards efficiency trend in which 75 to 85 percent of consumers purchase condensing equipment by 2055 by using the historical AHRI data to develop a future trend, but the Department points out that at present, the adoption of equipment equivalent to the standards proposed herein is currently about half of total shipments.[152] Thus, this final rule analysis assigns substantial credit to market-driven efficiency

[151] This database was developed using model data from DOE's Compliance Certification database (available at *www.regulations.doe.gov/certification-data/*) and manufacturer websites and catalogs.
[152] U.S. EPA. ENERGY STAR Unit Shipment and Market Penetration Report Calendar Year 2021 Summary. Available at *www.energystar.gov/sites/default/files/asset/document/2021%20Unit%20Shipment%20Data%20Summary%20Report_0.pdf*. Last accessed December 17, 2022.

accomplishments. DOE further notes that new and replacement markets were modeled using the same efficiency distributions.

For this final rule, DOE used the AHRI efficiency data to fit a Bass Diffusion curve, which shows continued market-driven efficiency improvements over the forecast period up to a point where 75 percent of commercial gas-fired storage and circulating water heaters and hot water supply boiler shipments are condensing in the no-new-standards case. For instantaneous tankless shipments, DOE modeled up to 85 percent of shipments in the condensing efficiency levels because it appears that presently, the percentage is much higher than for the other equipment types. Similarly, DOE used ENERGY STAR shipments of residential gas water heaters to fit a Bass Diffusion curve for the residential-duty equipment category, which shows continued market-driven efficiency improvement over the forecast period up to a point where 23 percent of residential-duty gas-fired storage water heater shipment are condensing in the no-new-standards case. DOE notes that the specification for the Bass Diffusion curve used a maximum of 75 percent; however, that maximum was not reached during the forecast period. Thus, an increasing efficiency trend is modeled over the 30-year analysis period in the NIA model for all equipment categories.

Table IV.29 shows the starting distribution of equipment by efficiency level. In the no-new-standards case, the distributions represent the starting point for analyzing potential energy savings and cumulative consumer impacts of potential standards for each equipment category.

Table IV.29 Market Shares by Efficiency Level in 2026*

Equipment		EL 0** %	EL1 %	EL2 %	EL3 %	EL4 %	EL5 %
Commercial gas-fired storage water heaters and gas-fired storage-type instantaneous water heaters		34	3	0	15	47	1
Residential-duty gas-fired storage water heaters		54	21	15	3	6	1
Gas-fired instantaneous water heaters and hot water supply boilers	Gas-fired tankless water heaters	17	0	0	4	22	57
	Gas-fired circulating water heaters and hot water supply boilers	5	13	13	2	11	55

* Due to rounding, shares for each row might not add to 100 percent.
** For the Residential-duty equipment class, efficiency is in terms of UEF. Because minimum UEF under the existing efficiency standard varies by storage tank size, equipment is categorized not by absolute value of UEF but by percentage point increases over the minimum efficiency required on the basis of the equipment's tank size.

For each efficiency level analyzed, DOE used a "roll-up" scenario to establish the market shares by efficiency level for the year that compliance would be required with potential standards. The analysis starts with the no-new-standards-case distributions wherein shipments are assumed to be distributed across efficiency levels as shown in Table IV.29. When potential standard levels above the base level are analyzed, as the name implies, the shipments in the no-new-standards case that did not meet the efficiency standard level being considered would roll up to meet the next higher standard level. The "roll-up" scenario also suggests that equipment efficiencies in the no-new-standards case that were above the standard level under consideration would not be affected. The no-new-standards-case efficiency distributions for each equipment class are discussed more fully in chapter 10 of the final rule TSD.

2. Fuel and Technology Switching

For this final rule, DOE analyzed whether amended standards would potentially create economic incentives for shifting between fuels, and specifically from natural gas to electricity, beyond any switching inherent in historical trends or due to electrification requirements, as discussed in section IV.G.4 of this document.

In comments filed in response to the May 2022 CWH ECS NOPR, Bradford White disagreed with DOE's assertion that moving to condensing levels would not lead to fuel switching in existing applications, noting that if products are unable to be vented for a variety of reasons, the commercial consumer will be forced to switch to one or more electric water heaters to meet their hot water needs. (Bradford White, No. 23 at p. 4) The Joint Gas Commenters stated that the proposed standards would cause entities to switch to electric products and raised concerns that EPCA does not permit DOE to establish standards that would drive consumers to switch fuel types. (Joint Gas Commenters, No. 34 at p. 39)

DOE acknowledges these concerns; however, DOE has determined (based upon the analyses described in this section) that the amended standard will not introduce additional economic incentives that would cause a noticeable increase in fuel switching from gas-fired CWH (and residential-duty) equipment to their electric counterparts. Accordingly, DOE did not explicitly include fuel or technology switching in this final rule beyond the continuation of historical trends and electrification requirements discussed in section IV.G.4 of this document. Additionally, DOE has previously received comments that condensing water heaters can be installed in lieu of noncondensing CWH equipment. For example, in comments received on the withdrawn May 2016 CWH ECS NOPR, HTP opined that given the various venting solutions available in the market, condensing water heater installation would be neither physically impossible nor prohibitively expensive, meaning these buildings would not end up "stranded." (DOE Docket EERE-2014-BT-STD-0042, HTP Inc., No. 44 at pp. 1–2) As another example, in comments received by NEEA,[153] they noted that "Even in cases that present significant challenges, interviewees reported that technical solutions were always possible" and that "Interviewees expressed that there is always a technical way to solve each of the retrofit problems that were identified, although sometimes the solutions may be expensive or out of line with what the building owner wants." (DOE Docket EERE-2018-BT-STD-0018, NEEA, No. 62 attached report at pp. 3, 6). DOE is cognizant that there may be higher cost installations that an individual building owner must weigh, and DOE has incorporated an extraordinary venting cost adder to account for these potential installations (see section IV.F.2.d).

For fuel and technology switching, DOE focused on whether the adopted standard would cause fuel switching based on economic factors, and did not consider additional fuel switching beyond the continuation of historical trends and electrification requirements discussed in section IV.G.4 of this document. DOE considered the effects of fuel switching by comparing total installed costs and operating costs of competing CWH equipment types. DOE conducted a high-level analysis by using average NIA

[153] NEEA, Northeast Energy Efficiency Partnerships, Pacific Gas & Electric, and National Grid. Joint comment response to the Notice of Petition for Rulemaking; request for comment (report attached – Memo: Investigation of Installation Barriers and Costs for Condensing Gas Appliances). Docket EERE-2018-BT-STD-0018, document number 62. *www.regulations.gov/comment/EERE-2018-BT-STD-0018-0062*. Last accessed July 8, 2021.

inputs and equipment operating hour data from the energy analysis to examine consumer PBPs in situations where they might switch from gas-fired to electric water heaters in both new and replacement construction at the proposed standard level. As previously noted, DOE is not analyzing thermal efficiency standards for electric storage water heaters since the thermal efficiency of these units already approaches 100 percent; as such, the underlying technology has most likely not changed, so for comparison purposes in this final rule, the installation, equipment, and maintenance and repair costs from the withdrawn May 2016 CWH ECS NOPR have been adjusted to account for inflation.[154] To make the costs comparable across equipment categories, DOE adjusted the average costs using ratios based on the first-hour ratings shown in Table IV.30.

Table IV.30 First-Hour Equipment Ratings Used in the Fuel Switching Analysis

Year	Commercial Gas-fired Storage Water Heaters	Residential-Duty Gas-fired Storage Water Heaters	Gas-fired Tankless Water Heaters	Gas-Fired Circulating Water Heaters and Hot Water Supply Boilers	Electric Storage Water Heaters
First-Hour Rating (gal)	283	134	268	664	165
Ratio to Commercial Gas-fired Storage	1.00	0.47	0.32*	2.34	0.58

* The ratio of the number of installed commercial gas-fired storage water heaters to installed gas-fired tankless water heaters is not directly comparable using only first-hour ratings, here based on a 90 °F temperature rise. The ratio shown reflects in-use delivery capability of the representative gas-fired tankless water heater model relative to the delivery capability of the representative commercial gas-fired storage water heater, and includes an estimated 3-to-1 delivery capability tradeoff for a tankless unit without storage compared to the representative gas storage water heater with the same first-hour rating.

[154] Electric storage water heater costs were escalated from 2014$ to 2022$ using gross domestic product price deflators. First year electricity costs were recalculated using the *AEO2023* prices for 2026, weighted by the percent of shipments to the commercial and residential markets for the comparison equipment class (commercial gas-fired or residential-duty).

DOE reviewed the installed cost of commercial electric and gas-fired storage water heaters, both at the no-new-standards-case efficiency level and with the standard level proposed herein for commercial gas-fired water heaters. The analysis uses costs for the year 2026 (in 2022$), the first year that an amended standard would be in effect. In new installations, the analysis assumes that the inflation-adjusted commercial electric storage water heater installed cost is $4,705 and the first year maintenance and repair cost is $54.[155] In replacement installations, the analysis assumes that the inflation-adjusted commercial electric storage water heater installed cost is $4,419 and the first year maintenance and repair cost is $54. In further investigating the potential for fuel-switching, DOE first scaled the first costs and the maintenance and repair costs of the electric storage water in new and replacement installations linearly with first-hour rating assuming that the consumer needs to meet the first hour capacity of the representative commercial gas-fired storage water heater. To better compare the electric energy use in a fuel switching scenario, DOE examined the average burner operating hours for the commercial gas water heater to meet the hot water load, as detailed in appendix 7B of the final rule TSD. By multiplying the input rating of the gas storage water heater by the baseline thermal efficiency and the average 3.23 hours of operation to meet the water load including piping losses (and not included standby burner operation), the average daily hot water provided by the unit was estimated at 513,718 Btu/day. Assuming a 100 percent conversion efficiency for the electric energy to provide this load would be would 150.56 kWh/day or 54,955 kWh/yr with an energy cost of $5,785 in the first year.

[155] Since the electric storage water heater was dropped from this final rule, for this analysis the MPC from the withdrawn 2016 ECS NOPR standby loss level 0 was used to represent no-new-standards-case electric storage water heaters.

DOE notes that this value does not account for additional energy for electric water heater standby losses.

With the electric water heater costs thus scaled and corresponding energy cost calculated, within new construction installations the commercial gas-fired storage water heater was estimated to be more expensive to purchase and install than the electric storage unit in both the no-new-standards and standards cases, but significantly less costly to operate (see Table IV.31). In these cases, the up-front cost premium of the commercial gas-fired storage unit at the amended standard level (TSL 3) relative to the scaled electric storage unit costs, divided by the annual operating savings for choosing the gas water heater, yields a PBP of 0.33 years, compared to a PBP of 0.22 years in the no-new-standards case. In replacement markets, the total installed cost of a commercial gas-fired storage unit was compared to the first-hour-rating scaled cost estimate for the commercial electric water heater as a replacement unit from the withdrawn May 2016 CWH ECS NOPR. The estimated total installed cost of the comparable electric storage unit exceeds the cost of the commercial gas-fired storage unit. As with new construction, the replacement electric storage unit is substantially more costly to operate.

Table IV.31 Typical Unit Costs, Scaled for First-Hour Rating (Commercial Gas-fired Storage = 1.0) – Electric Storage versus Commercial Gas-fired Storage (2022$)

Equipment	Cost	No-New-Standards Case New Construction	No-New-Standards Case Replacement*	Standards Case New Construction	Standards Case Replacement*
Electric Storage	Installed Cost	$8,070	$7,580	$8,070	$7,580
	Energy, Maintenance, and Repair Cost (First Year)	$5,878	$5,878	$5,955	$5,955
Commercial Gas-fired Storage	Installed Cost	$8,945	$5,642	$9,505	$7,298
	Energy, Maintenance, and Repair Cost (First Year)	$1,880	$1,962	$1,668	$1,735

* Installed costs for electric storage water heaters shown for the replacement case do not include cost of infrastructure alterations (e.g., upgraded wiring, removal or modification of gas infrastructure).

DOE further notes that, depending on the specifics of the commercial building, significant additional costs could be incurred in switching to electric storage water heaters if the existing building lacks the electrical wire capacity to where equivalent electrical water heater would be installed or related infrastructure (existing electrical panels, which may require the addition or upsizing of breakers, and electrical switchgear) to handle the input rating of a commercial electric storage water heater(s) that would meet the existing natural gas water heater capacity/load. Thus, DOE concludes that the amended standard will not cause a noticeable increase in fuel switching from commercial gas-fired to electric storage water heaters.

A similar analysis to that of the commercial gas-fired storage water heater and electric equivalent was repeated separately for residential-duty water heaters. The first costs and maintenance and repair costs were scaled by first hour rating to that equivalent to the representative residential-duty water heater. The hot water load for the electric equivalent unit was estimated based on the burner operating hours from appendix 7B of the TSD and the electric water heater energy costs were estimated assuming 100 percent conversion efficiency of the electric input to hot water load. For an electric water heater equivalent to a residential-duty gas water heater, the estimated energy consumption was 25,618 kWh/yr, equating to an energy cost of $2,853 in the first year. This value does not account for additional energy for electric water heater standby losses. The appropriately scaled first costs and operating cost estimates are shown in Table IV.32. In all but the no-new-standards replacement case, the residential-duty water heater is more expensive to install than the electric storage water heater; however, it was less costly to operate in all cases. For the cases in which the electric storage water heater was less expensive to install, the up-front cost premium of the gas-fired residential-duty unit relative to the electric storage unit, divided by the annual operating savings from using the gas water heater, yields a PBP of 0.11 years in the no-new-standards new installation case, of 0.21 years at the amended standard level (TSL 3) replacement case, and of 0.59 years at the amended standard level new installation case. Based on the comparison of costs for equivalent electric water heating, DOE concludes that amended standards would not introduce additional economic incentives for fuel switching from residential-duty to electric storage water heaters.

Table IV.32 Typical Unit Costs, Scaled for First-Hour Rating (Residential-duty = 1.0) – Electric Storage versus Residential-duty (2022$)

Equipment	Cost	No-New-Standards Case New Construction	No-New-Standards Case Replacement*	Standards Case New Construction	Standards Case Replacement*
Electric Storage	Installed Cost	$3,821	$3,589	$3,821	$3,589
	Energy, Maintenance, and Repair Cost (First Year)	$2,896	$2,897	$2,876	$2,876
Residential-duty Storage	Installed Cost	$4,014	$2,247	$4,922	$3,979
	Energy, Maintenance, and Repair Cost (First Year)	$1,180	$1,179	$997	$997

* Installed costs for electric storage water heaters shown for the replacement case do not include cost of infrastructure alterations (e.g., upgraded wiring, removal or modification of gas infrastructure).

In the May 2022 CWH ECS NOPR, DOE did not consider instantaneous gas-fired equipment and electric storage water heaters to be likely objects of gas-to-electric fuel switching, largely due to the disparity in hot water delivery capacity between the instantaneous gas-fired equipment and commercial electric storage equipment. In the May 2022 CWH ECS NOPR, DOE requested comment on the availability of systems that can be built by plumbing multiple individual water heaters together to achieve the same level of hot water delivery capacity. In response, AHRI, Rheem, and A.O. Smith all noted that CWH manufacturers currently offer product solutions that utilize one or more individual water heaters plumbed or racked together for hot water delivery. (AHRI, No. 31 at p. 4, Rheem, No. 24 at p. 6, A.O. Smith, No. 22 at p. 7) A.O. Smith described that many of these systems are highly customized; however, many manufacturers also offer systems that are preconfigured at the point of manufacture in ranges of total system capacity and are then sold as a single stock keeping unit (“SKU”). (A.O. Smith, No. 22 at p. 7) Rheem also suggested that these scalable hot water solutions in which multiple gas-fired instantaneous water heaters are combined may use water heaters that are individually rated, and the rack systems are distributed on an engineered-to-order basis with the additional rack system components (such as controllers and shut-off valves) sold separately alongside the water heaters. (Rheem, No. 24 at p. 6) Additionally, CA IOUs noted research that suggested commercial hot water systems that include multiple water heaters are common practice. (CA IOUs, No. 33 at p. 2) WM Technologies and Patterson-Kelley stated their understanding that several products are available like rack-type hot water heaters. In addition, the commenters stated the situation is limited by the first cost of installation and occurs predominantly in smaller commercial installations which employ multiple residential products to meet the hot water demand. WM Technologies and Patterson-Kelley stated these should be accounted for in the LCC model and that the deciding factor on use is cost with driving factors like venting, floor space, local code requirements, and possibly other causes. (WM Technologies, No. 25 at p. 8; Patterson-Kelley, No. 26 at p. 6) DOE appreciates the input from all commenters on the question about multiple individual water heaters being plumbed together. After reviewing the input from stakeholders on this issue, DOE believes that its analysis of gas-fired tankless water heating equipment, which already provides for multiple tankless water heaters to be used in a commercial building, sufficiently characterizes the LCC for this equipment and there is no need to consider these types of systems separately in the LCC analysis because operating costs and savings are similar, and additional costs associated with the racks and preconfiguration costs would likely be the same regardless of efficiency.

In its analysis of fuel switching DOE included tankless units, and as noted above, DOE believes the rack systems would have similar economic eventualities in the analysis of fuel switching, scaled up or down representing their use of multiple tankless units. As discussed, this analysis is similar to that of the commercial and residential-duty gas storage water heaters for the instantaneous water heater equipment categories as compared to an electric equivalent.

As with the commercial gas-fired and residential-duty storage water heaters, the first costs and maintenance and repair costs were scaled by first hour rating to the electric equivalent for the representative instantaneous tankless water heater. The hot water load for the electric equivalent unit was estimated based on the burner operating hours from appendix 7B of the TSD and the electric water heater energy costs were estimated assuming 100 percent conversion efficiency of the electric input to hot water load. For an electric water heater equivalent to an instantaneous tankless water heater, the estimated energy consumption was 15,338 kWh/yr, equating to an energy cost of $1,769 in the first year. This value does not account for additional energy for electric water heater standby losses. The appropriately scaled first costs and operating cost estimates are shown in Table IV.33. In all but the no-new-standards replacement case, the instantaneous water heater is more expensive to install than the electric storage water heater; however, it was less costly to operate in all cases. For the cases in which the electric storage water heater was less expensive to install, the up-front cost premium of the gas-fired instantaneous tankless unit relative to the electric storage unit, divided by the annual operating savings from using the gas water heater, yields a PBP of 2.00 years in the no-new-standards new installation case, of 1.26 years at the amended standard level (TSL 3) replacement case, and of 1.05 years at the amended standard level new installation case. Based on the comparison of costs for equivalent electric water heating, DOE concludes that amended standards would not introduce additional economic incentives for fuel switching from instantaneous tankless to electric storage water heaters.

Table IV.33 Typical Unit Costs, Scaled for First-Hour Rating (Instantaneous Tankless = 1.0) – Electric Storage versus Instantaneous Tankless (2022$)

Equipment	Cost	No-New-Standards Case New Construction	No-New-Standards Case Replacement*	Standards Case New Construction	Standards Case Replacement*
Electric Storage	Installed Cost	$2,582	$2,426	$2,582	$2,426
	Energy, Maintenance, and Repair Cost (First Year)	$1,799	$1,799	$1,798	$1,798
Instantaneous Tankless	Installed Cost	$4,790	$2,414	$3,834	$3,956
	Energy, Maintenance, and Repair Cost (First Year)	$694	$666	$610	$585

* Installed costs for electric storage water heaters shown for the replacement case do not include cost of infrastructure alterations (e.g., upgraded wiring, removal or modification of gas infrastructure).

Similarly, the first costs and maintenance and repair costs were scaled by first hour rating to that equivalent to the representative circulating water heater and hot water supply boiler. The hot water load for the electric equivalent unit was estimated based on the burner operating hours from appendix 7B of the TSD, and the electric water heater energy costs were estimated to assume 100 percent conversion efficiency of the electric input to hot water load. For an electric water heater equivalent to a circulating water heater and hot water supply boiler, the estimated energy consumption was 119,041 kWh/yr, equating to an energy cost of $12,405 in the first year. This value does not account for additional energy for electric water heater standby losses. The appropriately scaled first costs and operating cost estimates are shown in Table IV.34. In all cases, the circulating water heater and hot water supply boiler is less expensive to install and less costly to operate than the electric storage water. Based on the comparison of costs for equivalent electric water heating, DOE concludes that amended standards would not introduce additional economic incentives for fuel switching from circulating water heaters and hot water supply boilers to electric storage water heaters.

Table IV.34 Typical Unit Costs, Scaled for First-Hour Rating (Circulating Water Heater and Hot Water Supply Boiler = 1.0) – Electric Storage versus Circulating Water Heater and Hot Water Supply Boiler (2022$)

Equipment	Cost	No-New-Standards Case New Construction	No-New-Standards Case Replacement*	Standards Case New Construction	Standards Case Replacement*
Electric Storage	Installed Cost	$18,934	$17,785	$18,934	$17,785
	Energy, Maintenance, and Repair Cost (First Year)	$12,623	$12,623	$13,084	$13,084
Circulating Water Heater and Hot Water Supply Boiler	Installed Cost	$10,660	$6,455	$15,359	$13,301
	Energy, Maintenance, and Repair Cost (First Year)	$4,206	$4,377	$3,735	$3,861

* Installed costs for electric storage water heaters shown for the replacement case do not include cost of infrastructure alterations (e.g., upgraded wiring, removal or modification of gas infrastructure).

DOE recognizes that commercial tankless gas-fired water heaters could in theory be replaced with one or more electric tankless units. DOE notes that without hot water storage in such a system the instantaneous electric heating load could disproportionally impact a commercial buildings electric demand in many applications relative to the equivalent electric storage water heater, requiring greater electrical infrastructure upgrades as well as potentially higher and less predictable ongoing electric demand costs. DOE concludes that amended standards would not introduce additional economic incentives for fuel switching from gas-fired instantaneous tankless to electric storage or electric tankless water heaters. Similarly, replacement of gas fired circulating water heaters or boilers with an electric equivalent would be expected to require substantial electric capacity upgrades as well as much higher operating cost of the electric equipment. The representative 399 kBtu/h baseline gas-fired hot water boiler represents an approximately 94 kW electric instantaneous equivalent, anticipated to be a significant load increase to most commercial buildings that might otherwise use the gas-fired hot water boiler.

In summary, based upon the reasoning above, DOE did not explicitly include fuel or technology switching in this final rule beyond the continuation of historical trends and electrification requirements discussed in section IV.G.4 of this document.

3. National Energy Savings

The NES 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.

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 NEMS is the most appropriate tool for its FFC analysis and its intention to use NEMS 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[156] that EIA uses to prepare its *AEO*. The FFC factors incorporate 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 10D of the final rule TSD.

DOE calculated the NES associated with the difference between the per-unit energy use under a standards-case scenario and the per-unit energy use in the no-new-standards case. The average energy per unit used by the CWH equipment stock gradually

[156] For more information on NEMS, refer to *The National Energy Modeling System: An Overview 2018*, April 2019. Available at *www.eia.gov/forecasts/aeo/index.cfm* (last accessed December 13, 2022).

decreases in the standards case relative to the no-new-standards case as more-efficient CWH units gradually replaces less-efficient units.

Unit energy consumption values for each equipment category are taken from the LCC spreadsheet for each efficiency level and weighted based on market efficiency distributions. To estimate the total energy savings for each efficiency level, DOE first calculated the per-unit energy reduction (*i.e.*, the difference between the energy directly consumed by a unit of equipment in operation in the no-new-standards case and the standards case) for each category of CWH equipment for each year of the analysis period. The electricity and natural gas savings or increases (in the case of electricity used for condensing natural gas-fired water heaters) are accounted separately. Second, DOE determined the annual site energy savings by multiplying the stock of each equipment category by vintage (*i.e.*, year of shipment) by the per-unit energy reduction for each vintage (from step one). This second step adds to the electricity impacts an amount of energy savings/increase to account for the losses and inefficiencies in the generation, transmission, and distribution systems. The result of the second step yields primary electricity impacts at the generation source. The second step applies only to electricity; there is no analogous adjustment made to natural gas savings. Third, DOE converted the annual site electricity savings into the annual amount of energy saved at the source of electricity generation (the source or primary energy), using a time-series of conversion factors derived from the latest version of EIA's NEMS. This third step accounts for the energy used to extract and transport fuel from mines or wells to the electric generation facilities, and accounts for the natural gas NES for drilling and pipeline energy usage. The third step yields the total FFC impacts. DOE accounts for the natural gas savings separately from the electricity impacts, so the factors used at each step are appropriate for the specific fuel. The coefficients developed for the analysis are mutually exclusive, so there should be no double-counting of impacts. Finally, DOE summed the annual primary energy savings for the lifetime of units shipped over a 30-year period to calculate the total NES. DOE performed these calculations for each efficiency level considered for CWH equipment in this rulemaking. DOE notes that for the LCC and PBP analyses, only site energy impacts are used. The only steps in the analysis wherein FFC savings are used are the calculation of NES. DOE notes that the development of data for site-to-source and other factors is accomplished by running the EIA's model used to generate the *AEO*. DOE has included with this final rule TSD the previously mentioned chapter 10 and appendix 10D, which reference the development of the FFC factors and provide some of the underlying data.

Regarding the fossil fuel site-to-source values used in the final rule analysis, DOE used the *AEO2023* Reference case, which reflects the most up-to-date information on resource and fuel costs, but excludes Clean Power Plan ("CPP")[157] impacts. Use of the *AEO2023* also incorporates all Federal legislation and regulations in place when EIA prepared the analyses. The growing penetration of renewable electricity generation would have little effect on the trend in site-to-source energy factors because EIA uses an average fossil fuel heat to characterize the primary energy associated with renewable generation. At this time, DOE is continuing to use the "fossil fuel equivalency"

[157] The CPP was repealed in June 2019 as part of EPA's final Affordable Clean Energy ("ACE") Rule, but the ACE Rule was vacated in January 2021 by the United States Court of Appeals for the District of Columbia Circuit, who also remanded EPA to consider a new regulatory framework to replace the ACE Rule.

accounting convention used by EIA. DOE notes the *AEO* projections stop in 2050. Because the trends were relatively flat, DOE maintained the 2050 value for the remainder of the forecast period. When DOE develops the site-to-source and FFC-factors, it models resource mixes representative of the load profile of the equipment covered in the rulemaking that vary by end-use. For this final rule, DOE has used an average of resources compatible with the general load profile of CWH equipment, and the data used are the most current available.

DOE also considered whether a rebound effect is applicable in its NES analysis for CWH equipment. A rebound effect occurs when an increase in equipment efficiency leads to increased demand for its service. For example, when a consumer realizes that a more-efficient water heating device will lower the energy bill, that person may opt to increase his or her amenity level by taking longer showers and thereby consuming more hot water. In this way, the consumer gives up a portion of the energy cost savings in favor of the increased amenity. For the CWH equipment market, there are two ways that a rebound effect could occur: (1) increased use of hot water within the buildings in which such units are installed and (2) additional hot water outlets that were not previously installed. Because the CWH equipment addressed in this final rule is commercial equipment, the person owning the equipment (*i.e.*, the apartment or commercial building owner) is usually not the person operating the equipment (*e.g.*, the apartment renter, or the restaurant employee using hot water to wash dishes). Because the operator usually does not own the equipment, that person will not have the operating cost information necessary to influence his or her operation of the equipment. Therefore, the first type of rebound is unlikely to occur at levels that could be considered significant.

Similarly, the second type of rebound is unlikely because a small change in efficiency is insignificant among the factors that determine whether a company will invest the money required to pipe hot water to additional outlets. In response to the May 2022 CWH ECS NOPR, Atmos Energy stated that DOE should reconsider its conclusion that the proposed rule is unlikely to result in rebound effects on water usage and noted that some parts of the country are experiencing drought conditions. (Atmos Energy, No. 36 at p. 5) DOE recognizes that drought conditions may impact water usage within regions; however, the CWH equipment that is the subject of this rulemaking addresses only the heating of the water, and not the water usage itself, as water usage is based on demand and not the efficiency of the water heater. DOE had previously sought comments and data on any rebound effect that may be associated with more efficient commercial water heaters in the October 2014 RFI. 79 FR 62908 (Oct. 21, 2014) DOE received two comments. Both A.O. Smith and Joint Advocates did not believe a rebound effect would be significant. A.O. Smith commented that water usage is based on demand and more efficient water heaters would not change the demand. (DOE Docket EERE-2014-BT-STD-0042, A.O. Smith, No. 2 at p. 4) Joint Advocates commented that with the marginal change in energy bill for small business owners, they would expect little increased hot water usage, and that for tenant-occupied buildings, it would be "difficult to infer that more tenants will wash their hands longer because the hot water costs the building owner less." Thus, Joint Advocates thought the likelihood of a strong rebound effect is very low. (DOE Docket EERE-2014-BT-STD-0042, Joint Advocates, No. 7 at p. 5) DOE has therefore retained its position that a rebound effect is unlikely to occur for the CWH that are the subject of this final rule.

PHCC commented that the Department advanced this rule based on the significant energy savings of 0.7 quads. (PHCC, No. 28 at pp. 1) PHCC noted that totaling the energy use columns on the base case (no-new-standards) section of the NIA model spreadsheet for new units and replacement and switch units shows an approximate 6.5 quads, but if the total stock of units is extended, using even just the replacement energy yields 8.2 quads. PHCC stated it is important to make transparent comparisons; for example, using one way the 0.7 quads is an approximate 10 percent savings, and using the other is closer to 8.5 percent. (PHCC, No. 28 at pp. 1–2) PHCC further noted that commercial gas-fired storage water heaters and instantaneous circulating water heaters and hot water supply boilers are the major contributors and that the residential-duty gas-fired water heaters and instantaneous tankless water heaters are substantially less significant, and if evaluated individually, the significant energy savings argument would be even harder to make. (PHCC, No. 28 at p. 2)

As stated in section III.E.2, the significance of energy savings offered by an amended energy conservation standard cannot be determined without knowledge of the specific circumstances surrounding a given rulemaking. 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. Accordingly, taking these factors, among others into account, DOE has determined the energy savings for the TSL proposed in this rulemaking are “significant” within the meaning of EPCA.[158]

PHCC additionally questioned the NES calculations, noting that the energy savings appear to be based on the savings of equipment sold across the 30-year life cycle in the rule, but that it was not apparent what the total energy of the installed equipment or CWH equipment installed and currently in use might be. (PHCC, No. 28 at pp. 1) PHCC further stated that using the Department’s spreadsheets, it appears that the total energy used is for the newly installed equipment. (PHCC, No. 28 at pp. 1) PHCC stated that it is unclear how the 0.7 quads savings was derived. PHCC calculated a separate estimate of savings at 0.37 quads out of total energy consumed to be 8.2 quads. PHCC also noted that it has additional issues with assumptions made by the Department that would further erode the potential savings, but are difficult to quantify. (PHCC, No. 28 at p. 2) PHCC stated that based on its own review and understanding, PHCC questions the energy use and savings calculation that form the basis of the significant energy savings assertion. (PHCC, No. 28 at p. 6) PHCC also sought clarification as to the low energy use (site) in the early years of the Department’s analysis and noted that it appeared that there is no

[158] To the extent PHCC’s comments refer to a numeric savings threshold previously used to determine significance of energy savings, DOE notes that the numeric threshold for determining the significance of energy savings established in a final rule, Energy Conservation Program for Appliance Standards: Procedures for Use in New or Revised Energy Conservation Standards and Test Procedures for Consumer Products and Commercial/Industrial Equipment, published on February 14, 2020 (85 FR 8626, 8670), was subsequently eliminated in a final rule, Energy Conservation Program for Appliance Standards: Procedures, Interpretations, and Policies for Consideration in New or Revised Energy Conservation Standards and Test Procedures for Consumer Products and Commercial/Industrial Equipment, published on December 13, 2021 (86 FR 70892).

consideration of the energy usage of all existing covered products. (PHCC, No. 28 at p. 6)

In response, DOE would clarify that for its analysis, DOE considers only the impact of the proposed standard levels on equipment shipments that occur within the 2026 through 2055 analysis period. As a result, the estimated energy use in the early years of the analysis includes only equipment shipped for new and replacement applications beginning in 2026, and does not include the energy use of the existing equipment installed prior to 2026, the year in which the standard would go into effect. However, the NES does include the stream of energy savings that occurs over the life of the equipment installed during the analysis period, meaning that energy savings for a commercial gas-fired storage water heater installed in 2055 would be accrued throughout its life, beyond 2055 (see section IV.F.6 for a discussion of equipment lifetimes).

DOE further appreciates the effort that PHCC undertook to develop their calculations of energy use and energy savings, and notes that the PHCC calculations are similar to the DOE calculations within the NIA model. However, the DOE NIA model incorporates some additional calculations and factors to capture the energy accounting more fully. For each year beginning with 2026 (the first year that the standard would go into effect), energy use for both the no-new-standards case (labeled base case within the NIA spreadsheet's product tabs) and the selected efficiency level (labeled standards case) are calculated by multiplying the estimated number of installed units still surviving (which is equal to the installed units multiplied by a survival function) by the estimated unit energy use for the year in which they were installed. This calculation accounts for changes to the weighted average efficiencies installed in a given year, as the no-new-standards case has an increasing efficiency trend built into it. The NES is then calculated as the sum of the differences between the energy use calculated in the no-new-standards case and the energy use calculated in the standards case.

DOE observed that the screen captures of the PHCC calculations (PHCC, No. 28 at pp. 4–5) appear to contain only numbers for the commercial sector and do not seem to account for additional energy use and savings calculations for the residential sector (which can be viewed by selecting “Residential” in any of the application sector drop-down menus located throughout the model, as described in appendix 10A of the final rule TSD). Additionally, the PHCC calculations did not appear to account for the energy savings that accrue after 2055 from equipment installed through 2055 that had not yet reached their end of life. By summing the calculated site energy savings in the May 2022 CWH ECS NOPR NIA model (column CN within each of the product tabs of the NOPR NIA model), DOE calculated commercial site natural gas savings of 0.35 quads for the years 2026–2055, an additional 0.13 quads of commercial site natural gas savings beyond 2055 that accrue to equipment installed during the analysis period, and an additional 0.17 quads of residential sector site natural gas savings, yielding a total of 0.65 quads of site natural gas NES. DOE notes that the NES for the selected subset of years and commercial sector (0.35 quads) were similar to what PHCC calculated (0.37 quads). DOE also clarifies that the 0.70 quads referenced by PHCC are FFC NES, which explains the remaining difference between the site natural gas savings and the FFC savings; PHCC did not include the impact of changes in electricity due to proposed standards, which DOE also excluded here so as to produce a comparable set of numbers. With regard to

PHCC's additional unnamed issues with assumptions made by DOE, DOE notes that the underlying assumptions are made based on best available data and are meant to be representative of the equipment category while also allowing for a feasible analysis.

4. 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. DOE determined the difference between the equipment costs under the standard case and the no-new-standards case in order to obtain the net equipment cost increase resulting from the higher standard level. As noted in section IV.F.1 of this document, DOE used a constant real price assumption as the default price projection; the cost to manufacture a given unit of higher efficiency neither increases nor decreases over time. The analysis of the price trends is described in chapter 10 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 commercial energy price changes in the Reference case from *AEO2023*, which has an end year of 2050. To estimate price trends after 2050, the 2040-

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 10B of the final rule TSD.

DOE then determined the difference between the net operating cost savings and the net equipment cost increase in order to obtain the net savings (or expense) for each year. DOE then discounted the annual net savings (or expenses) to 2023 for CWH equipment bought on or after 2026 and summed the discounted values to provide the NPV for an efficiency level.

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 OMB to Federal agencies on the development of regulatory analysis.[159] 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.

[159] United States Office of Management and Budget. *Circular A-4: Regulatory Analysis*. September 17, 2003. Section E. Available at *www.whitehouse.gov/omb/information-for-agencies/circulars/* (last accessed December 13, 2022).

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.

DOE considered the possibility that consumers make purchase decisions based on first cost instead of LCC. DOE projects that new installations meeting a potential standard would not cause the commercial gas-fired storage water heaters to be significantly more expensive than electric storage water heaters of comparable first-hour capacity, as detailed in section IV.H.2 of this document. DOE further notes that only the relative costs of purchasing, installing, and operating equipment were considered in its analysis, and did not consider unrelated issues such as additional electrification of customer loads beyond those that have been adopted, as DOE cannot speculate about consumer electrification or other policies or issues (*see* sections IV.G and section IV.H.2 of this document).

DOE notes that governmental and corporate purchasing policies are increasingly resulting in purchases of more-efficient equipment. However, DOE does not infer anything with respect to the remaining market for efficient water heaters simply because of a purchase by one consumer or even by one segment of the consumer base, such as purchases by government consumers. In other words, if all Federal government agencies purchase ENERGY STAR-compliant water heaters, that tells us nothing about the installation costs experienced by any other consumers. DOE assumes the purchases reveal more about the underlying consumer discount rate premiums than about a distribution of installation costs. It is possible that corporate commitment to green purchasing policies might result in situations where, in their rational decision-making process, the consumer gives green purchase alternatives an explicit advantage. As an example, a purchasing policy may specify that that a “non-green” alternative must have a PBP of 3 years or less while a “green” alternative can have a PBP up to 5 years. This type of corporate decision making would have the outward appearance of providing an apparent discount rate advantage to the “green” alternative, or perhaps, an appearance of assessing a lower discount rate premium on the “green” alternative than is assessed on all other alternatives. Thus, while significant numbers of purchases are taking place in the market, DOE contends that such purchases reveal an underlying distribution of discount rate premiums rather than an underlying distribution of installation costs. Green policies and programs such as FEMP-designated equipment and ENERGY STAR will continue to effectively reduce even more consumers’ discount rate premiums, leading to more green purchases. This assumption underlies DOE’s decision to take the efficiency trends data provided by manufacturers and extend the trends into the future rather than holding efficiency constant at current rates.

I. Consumer Subgroup Analysis

In analyzing the potential impact of new or amended standards on consumers, DOE evaluates the impact on identifiable subgroups of consumers that may be disproportionately affected by a new or revised national energy conservation standard level. The purpose of a subgroup analysis is to determine the extent of any such disproportionate 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 identified consumers at the lowest income bracket in the residential sector and only included them for a residential sector subgroup analysis. The following provides further detail regarding DOE's consumer subgroup analysis. Chapter 11 in the final rule TSD describes the consumer subgroup analysis.

1. Residential Sector Subgroup Analysis

The RECS database divides the residential samples into 16 income bins. The income bins represent total gross annual household income. As far as discount rates are concerned, the survey of consumer finances divides the residential population into six different income bins: income bin 1 (0–20 percent income percentile), income bin 2 (20–40 percent income percentile), income bin 3 (40–60 percent income percentile), income bin 4 (60–80 percent income percentile), income bin 5 (80–90 percent income percentile), and income bin 6 (90–100 percent income percentile). In general, consumers in the lower income groups tend to discount future streams of benefits at a higher rate when compared to consumers in the higher income groups.

Hence, to analyze the influence of a national standard on the low-income group population, DOE conducted a (residential) subgroup analysis where only the 0–20 percent income percentile samples were included for the entire simulation run. Subsequently, the results of the subgroup analysis are compared to the results from all consumers.

The results of DOE's LCC subgroup analysis are summarized in section V.B.1.b of this final rule and described in detail in chapter 11 of the final rule TSD.

J. Manufacturer Impact Analysis

1. Overview

DOE performed an MIA to estimate the financial impacts of amended energy conservation standards on manufacturers of CWH equipment and to estimate the potential impacts of such standards on 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 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, equipment shipments, manufacturer markups, and investments in R&D and manufacturing capital required to produce compliant equipment. 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 ("TSLs"). To capture the uncertainty relating to manufacturer pricing strategies following amended standards, the GRIM estimates a range of possible impacts under different 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 CWH equipment manufacturing industry based on the market and technology assessment, preliminary manufacturer interviews, and publicly-available information. This included a top-down analysis of CWH equipment 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 CWH equipment manufacturing industry, including company filings of form 10-K from the SEC[160],

[160] U.S. Securities and Exchange Commission, Annual 10-K Reports (Various Years) (Available at *www.sec.gov/edgar/searchedgar/companysearch.html*).

corporate annual reports, the U.S. Census Bureau's Economic Census[161], and reports from Dunn & Bradstreet.[162]

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 CWH equipment in order to develop other key GRIM inputs, including product and capital conversion costs, and to gather additional information on 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,

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[161] U.S. Census Bureau, Annual Survey of Manufacturers: General Statistics: Statistics for Industry Groups and Industries (2021). Available at *www.census.gov/data/tables/time-series/econ/asm/2018-2021-asm.html*

[162] Dunn & Bradstreet Company Profiles, Various Companies. Available at *app.dnbhoovers.com*

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 ("LVMs"), 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, "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 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, 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 2055. DOE calculated INPVs by summing the stream of annual discounted cash flows during this period. For manufacturers of residential central air conditioners and heat pumps, DOE used a real discount rate of 9.1 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 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 and through written comments. The GRIM results are presented in section V.B.2. 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 equipment is typically more expensive than manufacturing baseline equipment due to the use of more complex components, which are typically more costly than baseline components. The changes in the MPCs of covered equipment can affect the revenues, gross margins, and cash flow of the industry. MPCs were derived in the engineering analysis, using methods discussed in section IV.C. For a complete description of the MPCs, see 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 2055 (the end year of the analysis period). See chapter 9 of the final rule TSD for additional details.

c. Conversion Costs and Stranded Assets

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 potential product conversion costs, DOE estimated the number of platforms manufacturers would have to modify to move their equipment lines to each incremental efficiency level. DOE developed the product conversion costs by estimating the amount of labor per platform manufacturers would need for research and development to raise the efficiency of models to each incremental efficiency level. DOE also assumed manufacturers would incur safety certification costs (including costs for updating safety certification records and for safety testing) associated with modifying their current product offerings to comply with amended standards.

To evaluate the level of capital conversion expenditures manufacturers would likely incur to comply with amended standards, DOE used information derived from the engineering analysis, equipment teardowns, and manufacturer interviews. DOE used the information to estimate the additional investments in property, plant, and equipment that are necessary to meet amended energy conservation standards. In the engineering analysis evaluation of higher efficiency equipment from leading manufacturers of commercial water heaters (both commercial duty and residential duty), DOE found a range of designs and manufacturing approaches. DOE attempted to account for both the range of manufacturing pathways and the current efficiency distribution of shipments in the modeling of industry capital conversion costs.

The capital conversion cost estimates for gas-fired storage water heaters are driven by the cost for industry to double production capacity at condensing efficiency levels. Those costs included, but were not limited to, capital investments in tube bending, press dies, machining, enameling, metal inert gas ("MIG") welding, leak testing, quality assurance stations, conveyer, and additional space requirements.

For gas-fired instantaneous water heaters capital conversion costs, DOE understands that manufacturers produce commercial models on the same production lines as residential models, which have much higher shipment volumes. As such, DOE modeled the scenario in which gas-fired instantaneous water heater manufacturers make incremental investments to increase production capacity, but do not need to setup entirely new production lines or new facilities to accommodate an amended standard requiring condensing technology for gas-fired instantaneous water heaters.

For gas-fired instantaneous circulating water heaters and hot water supply boilers, the design changes to reach condensing efficiency levels were driven by purchased parts (*i.e.*, condensing heat exchanger, burner tube, blower, gas valve). The capital conversion costs for this equipment class are based on incremental warehouse space needed to house additional purchased parts.

Rheem commented the conversion costs should reflect larger manufacturing space and more manufacturing time to produce a condensing unit, and the costs should reflect the expansion of existing facilities, expansion of assembly lines, and added shifts. (Rheem, No. 24 at p. 7) After the 2022 CWH ECS NOPR publication, DOE conducted additional manufacturer interviews at the request of industry. (AHRI, No.31 at p. 5; Rheem, No. 24 at p.1; Bock, No. 20 at p. 2) Where manufacturers provided estimates and analysis supporting updates to conversion costs, DOE incorporated the interview feedback into its estimation of investment levels. The interview feedback that DOE received was primarily focused on the gas-fired storage water heaters product class.

Bradford White commented that volume water heaters are not produced on the same production lines as residential products, and that volume water heaters are built in lower volumes and have different installation configurations than consumer water heaters. (Bradford White, No.23 at p. 9) DOE's conversion costs reflect Bradford

White's statements. DOE understands that volume water heaters are produced on lines dedicated to low-volume, commercial equipment.

In addition to capital and product conversion costs, amended energy conservation standards could create stranded assets, *i.e.*, tooling and equipment that were not yet fully depreciated and could have been used longer if energy conservation standards had not made them obsolete. In the compliance year, manufacturers write down the remaining undepreciated book value of existing tooling and equipment rendered obsolete by amended energy conservation standards.

To evaluate conversion costs manufacturers would likely incur to comply with amended standards, DOE used information derived from the engineering analysis, equipment teardowns, and manufacturer interviews. In conjunction with the evaluation of capital conversion costs, DOE estimated the portion of existing equipment, tooling, and conveyor that would be retired.

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 capital conversion costs, product conversion costs, and stranded assets, see chapter 12 of the final rule TSD.

d. Manufacturer Markup Scenarios

MSPs include 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 non-production cost markups to the MPCs estimated in the engineering analysis for each 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 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 markup scenario; and (2) a preservation of per-unit operating profit markup scenario. These scenarios lead to different 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" markup 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 an equipment category. As manufacturer production costs increase with efficiency, this scenario implies that the absolute dollar markup will increase.

To estimate the average manufacturer markup used in the preservation of gross margin percentage markup scenario, DOE analyzed publicly-available financial information for manufacturers of CWH equipment. DOE then requested feedback on its initial markup estimates during manufacturer interviews. The revised markups, which are used in DOE's quantitative analysis of industry financial impacts, are presented in Table IV.35 of this final rule. These markups capture all non-production costs, including SG&A expenses, R&D expenses, interest expenses, and profit.

Table IV.35 Manufacturer Markups for Preservation of Gross Margin Percentage Markup Scenario

Equipment		Markup
Commercial gas-fired storage and gas-fired storage-type instantaneous water heaters		1.45
Residential-duty gas-fired storage water heaters		1.45
Gas-fired instantaneous water heaters and hot water supply boilers	Tankless water heaters	1.43
	Circulating water heaters and hot water supply boilers	1.43

DOE also models the preservation of per-unit operating profit scenario because manufacturers stated that they do not expect to be able to mark up the full cost of production in the standards case, given the highly competitive nature of the CWH market. In this scenario, manufacturer markups are set so that operating profit 1 year after the compliance date of amended energy conservation standards is the same as in the no-new-standards case on a per-unit basis. In other words, manufacturers are not able to garner additional operating profit from the higher production costs and the investments that are required to comply with the amended standards; however, they are able to maintain the same per-unit operating profit in the standards case that was earned in the no-new-standards case. Therefore, operating margin in percentage terms is reduced between the no-new-standards case and standards case.

DOE adjusted the manufacturer markups in the GRIM at each TSL to yield approximately the same per-unit earnings before interest and taxes in the standards case as in the no-new-standards case. The preservation of per-unit operating profit markup scenario represents the lower bound of industry profitability in the standards case. This is because manufacturers are not able to fully pass through to commercial consumers the additional costs necessitated by amended standards for CWH equipment.

A comparison of industry financial impacts under the two markup scenarios is presented in section V.B.1.b of this document.

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 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 factors 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 Environmental Protection Agency ("EPA"). [163]

The onsite operation of CWH equipment involves combustion of fossil fuels and results in emissions of CO_2, NO_X, SO_2, CH_4, and N_2O where this equipment is 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.[164]

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.

[163] Available at www.epa.gov/sites/production/files/2021-04/documents/emission-factors_apr2021.pdf (last accessed December 22, 2022).
[164] 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 December 22, 2022).

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 NIA.

1. Air Quality Regulations Incorporated in DOE's Analysis

DOE's no-new-standards case for the electric power sector reflects the *AEO2023*, which incorporates the projected impacts of existing air quality regulations on emissions. *AEO2023* generally represents current legislation and environmental regulations, including recent government actions, that were in place at the time of preparation of *AEO2023*, including the emissions control programs discussed in the following paragraphs. [165]

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

[165] 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 April 13, 2023).

effect as of January 1, 2015.[166] *AEO2023* 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.

However, beginning in 2016, SO_2 emissions began to fall as a result of the Mercury and Air Toxics Standards ("MATS") for power plants. 77 FR 9304 (Feb. 16, 2012). In the MATS final rule, EPA established a standard for hydrogen chloride as a surrogate for acid gas hazardous air pollutants ("HAP") and also established a standard for SO_2 (a non-HAP acid gas) as an alternative equivalent surrogate standard for acid gas HAP. The same controls are used to reduce HAP and non-HAP acid gas; thus, SO_2 emissions are being reduced as a result of the control technologies installed on coal-fired power plants to comply with the MATS requirements for acid gas. In order to continue operating, coal plants must have either flue gas desulfurization or dry sorbent injection systems installed. Both technologies, which are used to reduce acid gas emissions, also

[166] 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-September) 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).

reduce SO_2 emissions. 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 energy conservation 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 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 impact Hg emissions. DOE estimated mercury emissions reduction using emissions factors based on *AEO2023*, which incorporates the MATS.

In comments, Rheem stated some consumers will elect to switch from gas-fired to electric water heaters in response to difficult installations to switch from non-condensing to condensing, and that DOE should consider how the electricity grid produces energy in DOE's climate analysis. Rheem stated that in some regions, the use of electricity generated from coal to power electric water heaters will increase emissions compared to a gas water heater. (Rheem, No. 24 at p. 8). Similarly, Suburban Propane expressed concern that the proposed standards would produce more, rather than less, greenhouse gas emissions in most of the country due to lack of consideration of lower-carbon and carbon-negative energy sources such as traditional and renewable propane. (Suburban Propane, No. 16 at pp. 2–3) Suburban Propane stated that the proposed standards would effectively mandate that only electric energy be used for future water heating needs, causing additional strain to the electric infrastructure and leading to increased carbon emissions. *Id*. Suburban Propane added that traditional propane is an abundant, domestically produced energy source and is defined as a clean alternative fuel under the 1990 Clean Air Act. *Id*. Suburban Propane encouraged DOE to focus on a technology-neutral approach that requires low carbon and carbon negative fuel sources, such as a clean fuel standard for building emissions. *Id*.

Because DOE has no authority over questions such as whether a company might electrify loads or future state policies about electrification, DOE is limiting the response to these comments to the matters arising because of this final rule. As noted throughout this final rule, under EPCA DOE can only set standards for CWH equipment if such does not result in the elimination of products or product features from the market, and if clear and convincing evidence exists to support the standard. DOE believe both of these conditions exist, and that the outcome described in the Suburban Propane comment where the standard effectively becomes an electric-only mandate will not come to pass as a result of this final rule. As discussed in section IV.H.2 of this document, DOE believes that generally the final rule will not induce fuel switching. Rheem's comment addresses a more specific case, that of the difficult installation. DOE notes that consumers facing difficult installations using vertical venting may have cost-effective alternatives such as horizontal venting. DOE notes based on the NEEA report the number of difficult installations is expected to be small. Add to this the fact that bringing multiple tens of kW or more of electric power to the existing commercial water heater(s) location including wiring, switching, breaker panels and other internal building changes to effect fuel switching in existing buildings, may be costly itself making the economics of fuel switching, particularly to a more expensive water heating fuel not an attractive option for existing buildings. DOE believes the number of installations that would fuel switch is small enough to not materially change the results posted in this final rule.

Bradford White recommended that DOE take into account other regulatory actions, including those at the state level (*i.e.*, California) that will reduce NOx emissions regardless of the outcome of this rulemaking to avoid potentially double counting reduced emissions. (Bradford White, No. 23 at pp. 6–7) Bradford White recommended that DOE take into account other regulatory actions, including those at the state level (*i.e.*, California) that will reduce NOx emissions regardless of the outcome of this rulemaking to avoid potentially double counting reduced emissions. (Bradford White, No. 23 at pp. 6–7) In response, DOE has found that pre-mix burners are the primary technology used to produce low, and ultra-low NOx emitting equipment. (Docket No. EERE-2017-BT-STD-0019, chapter 5) As Bradford White notes, DOE does not explicitly model the quantity of these low- and ultra-low NOx units to NOx regulated states in its baseline consumer sample. In a standard that results in consumers migrating from atmospheric burners to the types of pre-mix burners used to achieve condensing-level efficiencies, as required in this rule, NOx reductions would occur from reduction of energy used at the site (as well as upstream from the site). In DOE's emissions quantification, the emissions benefit from the reduction of energy use is considered directly. However, the additional reduction from the type of combustion system used has not been quantified. While Bradford White is correct that DOE did not explicitly address the extent of NOx emissions benefits in NOx-regulated geographic areas, DOE does account for the large fraction of consumers already purchasing condensing equipment, with powered burners, in its base case (see section IV.F.8 of this document). To the extent that consumers in NOx regulated geographic areas preferentially purchase high-efficiency equipment with pre-mix burners to meet these NOx regulations, this mitigates potential double counting. Further, the analysis conducted by DOE examines the emissions benefits from reduction of natural gas consumption due to efficiency improvements. However, because of the burner technology shift necessary to achieve the higher efficiency levels and the correlated reduction in NOx emissions in the shift in burner technology, DOE believes there will be additional NOx emission reductions across the United States and these are not captured in DOE's analysis. DOE believes that these additional benefits will offset any remaining double counting in NOx-regulated geographies.

Bradford White recommend DOE also analyze additional emissions generated to comply with an amended standard. (Bradford White, No. 23 at p. 6) With an amended standard, more components, including more complex components and more of certain existing components will be required to comply. Bradford White suggested that this begged the question whether more emissions would be generated to produce components to comply with an amended standard versus what emissions will be saved by requiring higher efficiency equipment. (Bradford White, No. 23 p. 6) In section IV.F.10 of this document, DOE addressed the comments related to embodied emissions posted by WM Technologies and Patterson-Kelley. EPCA authorizes DOE to promulgate rules regulating the energy efficiency of CWH equipment, but this authority does not extend to regulating or considering the means by which manufacturers produce CWH equipment. DOE quantifies the emissions reductions generated by the estimated energy savings as part of the analysis relevant to its implementation of its authority to regulate energy efficiency. Given DOE's lack of authority over manufacturers' processes, DOE also has no mechanism for effecting change. Therefore, DOE declines at present to quantify these embodied emissions as they are outside the scope of DOE's authority and analysis of energy efficiency of covered equipment.

L. Monetizing Emissions Impacts

As part of the development of this final rule, for the purpose of complying with the requirements of E.O. 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

For the purpose of complying with the requirements of E.O. 12866, DOE estimates the monetized benefits of the reductions in emissions of CO_2, CH_4, and N_2O by using a measure of the social cost ("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 rule in the absence of the SC-GHG, including the February 2021 Interim Estimates presented by the IWG. The social costs of greenhouse gases, whether measured using the February 2021 interim estimates presented by the IWG or by another means, did not affect the rule ultimately proposed by DOE.

DOE estimated the global social benefits of CO_2, CH_4, and N_2O reductions (*i.e.*, SC-GHGs) using the 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. The SC-GHGs 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, 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 agrees that the interim SC-GHG estimates represent the most appropriate estimate of the SC-GHG until revised estimates have been developed reflecting the latest, peer-reviewed science.

The SC-GHG estimates presented here were developed over many years, using transparent process, peer-reviewed methodologies, the best science available at the time of that process, and input from the public. Specifically, in 2009, the IWG, that included the DOE and other executive branch agencies and offices was established to ensure that agencies were using the best available science and to promote consistency in the SC-CO_2 values used across agencies. The IWG published SC-CO_2 estimates in 2010 that were developed from an ensemble of three widely cited integrated assessment models ("IAMs") that estimate global climate damages using highly aggregated representations of climate processes and the global economy combined into a single modeling framework. The three IAMs were run using a common set of input assumptions in each model for future population, economic, and CO_2 emissions growth, as well as equilibrium climate sensitivity ("ECS")– a measure of the globally averaged temperature response to increased atmospheric CO_2 concentrations. These estimates were updated in 2013 based on new versions of each IAM. In August 2016 the IWG published estimates of the SC-CH_4 and SC-N_2O using methodologies that are consistent with the methodology underlying the SC-CO_2 estimates. The modeling approach that extends the IWG SC-CO_2 methodology to non-CO_2 GHGs has undergone multiple stages of peer review. The SC-CH_4 and SC-N_2O estimates were developed by Marten *et al.*[167] and underwent a standard double-blind peer review process prior to journal publication.

[167] Marten, A. L., E. A. Kopits, C. W. Griffiths, S. C. Newbold, and A. Wolverton. Incremental CH4 and N2O mitigation benefits consistent with the US Government's SC-CO2 estimates. *Climate Policy*. 2015. 15(2): pp. 272–298.

In 2015, as part of the response to public comments received to a 2013 solicitation for comments on the SC-CO_2 estimates, the IWG announced a National Academies of Sciences, Engineering, and Medicine review of the SC-CO_2 estimates to offer advice on how to approach future updates to ensure that the estimates continue to reflect the best available science and methodologies. In January 2017, the National Academies released their final report, *Valuing Climate Damages: Updating Estimation of the Social Cost of Carbon Dioxide*, and recommended specific criteria for future updates to the SC-CO_2 estimates, a modeling framework to satisfy the specified criteria, and both near-term updates and longer-term research needs pertaining to various components of the estimation process.[168] Shortly thereafter, in March 2017, President Trump issued E.O. 13783, which disbanded the IWG, withdrew the previous TSDs, and directed agencies to ensure SC-CO_2 estimates used in regulatory analyses are consistent with the guidance contained in OMB's Circular A-4, "including with respect to the consideration of domestic versus international impacts and the consideration of appropriate discount rates" (E.O. 13783, Section 5(c)). Benefit-cost analyses following E.O. 13783 used SC-GHG estimates that attempted to focus on the U.S.-specific share of climate change damages as estimated by the models and were calculated using two discount rates recommended by Circular A-4, 3 percent and 7 percent. All other methodological decisions and model versions used in SC-GHG calculations remained the same as those used by the IWG in 2010 and 2013, respectively.

[168] National Academies of Sciences, Engineering, and Medicine. *Valuing Climate Damages: Updating Estimation of the Social Cost of Carbon Dioxide*. 2017. The National Academies Press: Washington, DC.

On January 20, 2021, President Biden issued E.O. 13990, which re-established the IWG and directed it to ensure that the U.S. Government's estimates of the SC-CO_2 and SC-GHG reflect the best available science and the recommendations of the National Academies. The IWG was tasked with first reviewing the SC-GHG estimates currently used in Federal analyses and publishing interim estimates within 30 days of the Executive Order that reflect the full impact of GHG emissions, including by taking global damages into account. The interim SC-GHG estimates published in February 2021 are used here to estimate the climate benefits for this rule. The Executive Order instructs the IWG to undertake a fuller update of the SC-GHG estimates by January 2022 that takes into consideration the advice of the National Academies and other recent scientific literature.

The February 2021 SC-GHG TSD provides a complete discussion of the IWG's initial review conducted under E.O.13990. In particular, the IWG found that the SC-GHG estimates used under E.O. 13783 fail to reflect the full impact of GHG emissions in multiple ways. First, the IWG found that the SC-GHG estimates used under E.O. 13783 fail to fully capture many climate impacts that affect the welfare of U.S. citizens and residents, and those impacts are better reflected by global measures of the SC-GHG. Examples of omitted effects from the E.O. 13783 estimates include direct effects on U.S. citizens, assets, and investments located abroad, supply chains, U.S. military assets and interests abroad, tourism, spillover pathways such as economic and political destabilization, and global migration that can lead to adverse impacts on U.S. national security, public health, and humanitarian concerns. In addition, assessing the benefits of U.S. GHG mitigation activities requires consideration of how those actions may affect mitigation activities by other countries, as those international mitigation actions will provide a benefit to U.S. citizens and residents by mitigating climate impacts that affect U.S. citizens and residents. A wide range of scientific and economic experts have emphasized the issue of reciprocity as support for considering global damages of GHG emissions. If the United States does not consider impacts on other countries, it is difficult to convince other countries to consider the impacts of their emissions on the United States. The only way to achieve an efficient allocation of resources for emissions reduction on a global basis—and so benefit the United States and its citizens—is for all countries to base their policies on global estimates of damages. As a member of the IWG involved in the development of the February 2021 SC-GHG TSD, DOE agrees with this assessment and, therefore, in this rule DOE centers attention on a global measure of SC-GHG. This approach is the same as that taken in DOE regulatory analyses from 2012 through 2016. A robust estimate of climate damages that accrue only to U.S. citizens and residents does not currently exist in the literature. As explained in the February 2021 TSD, existing estimates are both incomplete and an underestimate of total damages that accrue to the citizens and residents of the United States because they do not fully capture the regional interactions and spillovers discussed above, nor do they include all of the important physical, ecological, and economic impacts of climate change recognized in the climate change literature. As noted in the February 2021 SC-GHG TSD, the IWG will continue to review developments in the literature, including more robust methodologies for estimating a U.S.-specific SC-GHG value, and explore ways to better inform the public of the full range of carbon impacts. As a member of the IWG, DOE will continue to follow developments in the literature pertaining to this issue.

Second, the IWG found that the use of the social rate of return on capital (7 percent under current OMB Circular A-4 guidance) to discount the future benefits of reducing GHG emissions inappropriately underestimates the impacts of climate change for the purposes of estimating the SC-GHG. Consistent with the findings of the National Academies and the economic literature, the IWG continued to conclude that the consumption rate of interest is the theoretically appropriate discount rate in an intergenerational context,[169] and recommended that discount rate uncertainty and relevant aspects of intergenerational ethical considerations be accounted for in selecting future discount rates.

Furthermore, the damage estimates developed for use in the SC-GHG are estimated in consumption-equivalent terms, and so an application of OMB Circular A-4's guidance for regulatory analysis would then use the consumption discount rate to calculate the SC-GHG. DOE agrees with this assessment and will continue to follow developments in the literature pertaining to this issue. DOE also notes that while OMB Circular A-4, as published in 2003, recommends using 3 percent and 7 percent discount

[169] Interagency Working Group on Social Cost of Carbon. Social Cost of Carbon for Regulatory Impact Analysis under Executive Order 12866. 2010. United States Government. (Last accessed April 15, 2022.) *www.epa.gov/sites/default/files/2016-12/documents/scc_tsd_2010.pdf*; Interagency Working Group on Social Cost of Carbon. Technical Update of the Social Cost of Carbon for Regulatory Impact Analysis Under Executive Order 12866. 2013. (Last accessed April 15, 2022.) *www.federalregister.gov/documents/2013/11/26/2013-28242/technical-support-document-technical-update-of-the-social-cost-of-carbon-for-regulatory-impact*; Interagency Working Group on Social Cost of Greenhouse Gases, United States Government. Technical Support Document: 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*; Interagency Working Group on Social Cost of Greenhouse Gases, United States Government. Addendum to Technical Support Document on Social Cost of Carbon for Regulatory Impact Analysis under Executive Order 12866: Application of the Methodology to Estimate the Social Cost of Methane and the Social Cost of Nitrous Oxide. August 2016. (Last accessed January 18, 2022.) *www.epa.gov/sites/default/files/2016-12/documents/addendum_to_sc-ghg_tsd_august_2016.pdf.*

rates as “default” values, Circular A-4 also reminds agencies that “different regulations may call for different emphases in the analysis, depending on the nature and complexity of the regulatory issues and the sensitivity of the benefit and cost estimates to the key assumptions.” On discounting, Circular A-4 recognizes that “special ethical considerations arise when comparing benefits and costs across generations,” and Circular A-4 acknowledges that analyses may appropriately “discount future costs and consumption benefits…at a lower rate than for intragenerational analysis.” In the 2015 Response to Comments on the Social Cost of Carbon for Regulatory Impact Analysis, OMB, DOE, and the other IWG members recognized that “Circular A-4 is a living document” and “the use of 7 percent is not considered appropriate for intergenerational discounting. There is wide support for this view in the academic literature, and it is recognized in Circular A-4 itself.” Thus, DOE concludes that a 7 percent discount rate is not appropriate to apply to value the SC-GHG in the analysis presented in this analysis.

To calculate the present and annualized values of climate benefits, DOE uses the same discount rate as the rate used to discount the value of damages from future GHG emissions, for internal consistency. That approach to discounting follows the same approach that the February 2021 TSD recommends “to ensure internal consistency—*i.e.*, future damages from climate change using the SC-GHG at 2.5 percent should be discounted to the base year of the analysis using the same 2.5 percent rate.” DOE has also consulted the National Academies’ 2017 recommendations on how SC-GHG estimates can “be combined in RIAs with other cost and benefits estimates that may use different discount rates.” The National Academies reviewed several options, including "presenting all discount rate combinations of other costs and benefits with [SC-GHG] estimates."

As a member of the IWG involved in the development of the February 2021 SC-GHG TSD, DOE agrees with the above assessment and will continue to follow developments in the literature pertaining to this issue. While the IWG works to assess how best to incorporate the latest, peer reviewed science to develop an updated set of SC-GHG estimates, it set the interim estimates to be the most recent estimates developed by the IWG prior to the group being disbanded in 2017. The estimates rely on the same models and harmonized inputs and are calculated using a range of discount rates. As explained in the February 2021 SC-GHG TSD, the IWG has recommended that agencies revert to the same set of four values drawn from the SC-GHG distributions based on three discount rates as were used in regulatory analyses between 2010 and 2016 and were subject to public comment. For each discount rate, the IWG combined the distributions across models and socioeconomic emissions scenarios (applying equal weight to each) and then selected a set of four values recommended for use in benefit-cost analyses: an average value resulting from the model runs for each of three discount rates (2.5 percent, 3 percent, and 5 percent), plus a fourth value, selected as the 95th percentile of estimates based on a 3 percent discount rate. The fourth value was included to provide information on potentially higher-than-expected economic impacts from climate change. As explained in the February 2021 SC-GHG TSD, and DOE agrees, this update reflects the immediate need to have an operational SC-GHG for use in regulatory benefit-cost analyses and other applications that was developed using a transparent process, peer-reviewed methodologies, and the science available at the time of that process. Those estimates were subject to public comment in the context of dozens of proposed rulemakings as well as in a dedicated public comment period in 2013.

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.[170] 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 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

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[170] Interagency Working Group on Social Cost of Greenhouse Gases (IWG). 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/*.

work in the same direction in terms of their influence on the SC-CO_2 estimates. However, as discussed in the February 2021 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.

In comments filed in response to the May 2022 CWH ECS NOPR, Joint Climate Commenters stated that DOE appropriately applies the social cost estimates developed by the IWG for CO_2, CH_4, and N_2O, to its analysis of emission reduction benefits. The Joint Climate Commenters added that those values are widely agreed to underestimate the full SC-GHG emissions but are appropriate to use as conservative estimates, have been used in dozens of previous rulemakings, and were upheld in federal court. (Joint Climate Commenters, No. 19 at pp. 1–2). The Joint Climate Commenters suggested that DOE should expand upon its rationale for adopting a global damages valuation and for the range of discount rates it applies to climate effects, and should also strongly consider conducting supplemental sensitivity analyses to assess the proposed rule's climate benefits at lower discount rates, as recommended by the IWG. (Joint Climate Commenters, No. 20 at p. 2). The Joint Climate Commenters also stated that DOE should provide additional support for adopting a global framework for valuing climate impacts, including providing legal justifications based on applicable requirements placed on DOE. In particular, the Joint Climate Commenters suggested that DOE could strengthen is economic and policy justifications by explicitly concluding that the theory and evidence for international reciprocity justify a focus on the full global values. However, they stated that DOE should also consider including a discussion of domestic-only estimates and should consider conducting sensitivity analysis using a sounder domestic-only estimate as a backstop, and should explicitly conclude that the rule is cost-benefit justified even using a domestic-only valuation that may still undercount climate benefits. (Joint Commenters, No. 21 at p. 2) The Joint Climate Commenters also stated that DOE should consider including additional justification for adopting the range of discount rates endorsed by the IWG and for appropriately deciding not to apply a 7 percent capital-based discount rate to climate impacts. In particular, they suggested that DOE should provide additional justification for combining climate effects discounted at an appropriate consumption-based rate with other costs and benefits discounted at a capital-based rate. The Joint Climate Commenters suggested that it is appropriate generally to focus its analysis of this rule on consumption-based rates given that most costs and benefits are projected to fall to consumption rather than to capital investments. (Joint Commenters, No. 22 at pp. 2–3) The Joint Climate Commenters also suggested that DOE should also consider providing additional sensitivity analysis using discount rates of 2 percent or lower for climate impacts, as recently suggested by the Working Group. (Joint Climate Commenters, No. 23 at p. 3) The Joint Climate Commenters stated that DOE should consider adding further justification for relying on the Working Group's other methodological choices, including the fact that the Working Group applied a transparent and rigorous process that relied upon the best-available and most widely cited models for monetizing climate damages. In support of this, they included several attachments which they said provide detailed rebuttals to common criticisms of the Working Group's methodology. (Joint Climate Commenters, No. 24 at p. 3) DOE acknowledges that interim 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 interim SC-GHG estimates represent the most appropriate estimate of the SC-GHG until revised estimates have been developed reflecting the latest, peer-reviewed science. The IWG February 2021 TSD provides further justification for use of global SC-GHG estimates.

The Joint Climate Commenters encouraged DOE to clearly state that any criticisms of the social cost of greenhouse gases are moot in this rulemaking because the Proposed Rule is easily cost-justified without any climate benefits. (Joint Climate Commenters, No. 25 at p. 3) DOE acknowledges that this rule is economically justified without SC-GHG and health benefits, but notes that consideration of those benefits and costs is important when determining the impact to the nation.

The Associations state that DOE should not rely on the SC-GHG for any decision-making until the procedural shortcomings in the SC-GHG development have been addressed, alleging that the development of SC-GHG needs to be developed through a process consistent with the Administrative Procedure Act and that the current SC-GHG was not. (The Associations, No. 32 at pp. 2–3) The Associations stated that the SC-GHG was issued in 2021 without prior notice and no public comment period. The Associations alleged this process lacked transparency, and by extension the DOE NOPR process lacked transparency insofar as it does not provide a full IWG process record for the public to comment on. The Associations commented that without such a record, the public's ability to comment meaningfully is impaired. They further stated that a future comment period in the IWG process does not provide remedy. (The Associations, No. 32

at p. 3) The Associations stated additionally that the original social cost of carbon comment period in 2013 did not reflect a meaningful opportunity to comment, lacked a peer review process, and did not provide the public access to information underlying the estimates. This period predated the SC-CH_4 and SC-N_2O, which the Associations alleged were also not subject to public input. (The Associations, No. 32 at p. 4) The Associations stated that DOE should further not use the SC-GHG because the IWG has yet to fully consider recommendations for improvement made by the National Academy of Sciences. (The Associations, No. 32 at p. 4) DOE notes as stated above that interim 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 interim SC-GHG estimates represent the most appropriate estimate of the SC-GHG until revised estimates have been developed reflecting the latest, peer-reviewed science.

The Associations stated that the SC-GHG estimates do not comply with OMB guidance on information quality because the IWG failed to follow OMB's guidance for peer review, and therefore use by DOE could be considered arbitrary and capricious. They noted further that the IWG also failed to meet OMB's requirements for a formal uncertainty analysis. (The Associations, No. 32 at pp. 4-5) The Associations also pointed out that the discount rates used do not comport with OMB's Circular A-4, which requires use of 3 and 7 percent discount rates, and note that A-4 remains the governing guidance for regulatory cost-benefit analyses. They urged DOE to comply with Circular A-4 in all relevant aspects. (The Associations, No. 32 at p. 5) DOE notes in response that DOE uses discount rates consistent with findings of the National Academies, economic literature, and the IWG. Circular A-4 recognizes that "special ethical considerations arise when comparing the benefits and costs across generations." Circular A-4 acknowledges that analyses may appropriately "discount future costs and consumption benefits…at a lower rate than for intragenerational analysis." See Circular A-4 at 36. DOE will continue to follow developments in the literature pertaining to this issue.

The Associations recommended DOE state clearly the statutory authority for applying SC-GHG estimates in the rulemaking and that DOE "articulate the principles that will allow private parties to predict future applications of such estimates in domains governed by the particular statutory provisions." (The Associations, No. 32 at pp. 2 and 7) The Associations urged DOE to consider whether the "major questions doctrine" applies to DOE's use of the SC-GHG estimates "because the SC-GHG estimates are of such major economic and political significance". *Id.* at 7. The Associations liken the use of SC-GHG to effectively serving as a fee for GHG emissions and note that Congress has not established GHG taxes or fees. Thus, the Associations state their opinion that SC-GHG usage falls under the major questions doctrine and urge DOE to therefore not use the SC-GHG estimates. (The Associations, No. 32 at pp. 2–3 and 8) The Associations note the change in levels of SC-GHG between Administrations and use such as evidence that choices might involve policy judgements requiring an express delegation from Congress. (The Associations, No. 32 at p. 8)

DOE notes first that, under EPCA, the Department regulates only the energy efficiency or use of CWHs. DOE does not regulate the emissions of CWHs or the emissions of energy sources used to generate energy for those water heaters. While DOE does not regulate emissions under EPCA, DOE is required to determine the benefits and burdens of an energy conservation standard. (*See* 42 U.S.C. 6313(a)(6)(B)(ii)) Emissions reductions are one of the benefits that DOE considers when weighing the possibility of more-stringent energy conservation standards. And in compliance with E.O. 12866 and E.O. 13990, and for the reasons described above, DOE is using the SC-GHG estimates to quantify the value of those emissions reductions. [171]

Patterson-Kelley and WM Technologies commented regarding the Supreme Court ruling in West Virginia v. EPA. Patterson-Kelley is concerned over the emissions impact analysis in the commercial water heater rulemaking, as it is likely to require rollback of any efficiency rulemaking. (Patterson-Kelley, No. 26 at pp. 1–2, 7; WM Technologies, No. 25 at pp. 1 and 9) DOE notes this final rule is economically justified without including net benefits related to emissions. Thus, if the Supreme Court or any other court acted to curtail the consideration of the benefits arising from emissions reductions, this rule is not dependent on the value of such benefits and should not be affected.

In comments, PHCC stated that while DOE presented much information on the social costs of climate emissions as well as related health costs of emission, it is unclear how the Department intends to use this information, noting that on occasion it is stated that the proposal pays for itself without these factors, while at the same time stressing these factors' importance. PHCC asked why DOE would engage in the debate if the rule

[171] For more information, see 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.

is economically justified without these factors. (PHCC, No. 28 at p. 11) DOE acknowledges the rule is economically justified without SC-GHG and health impacts. However, understanding SC-GHG and health benefits and costs is part of describing clearly the total impact of energy efficiency standards, and they are relevant considerations for the public and stakeholders.

PHCC also questioned the Department's authority to regulate emissions and notes the language of the statute directs DOE to deal with energy, not emissions, and that this topic is a matter of current litigation, which the Department acknowledges. PHCC would like clarification as to the status of this rule should this question ultimately be ruled contrary to the opinion of DOE. (PHCC, No. 28 at p. 11) In response, DOE notes again that it does not regulate emissions for covered products and equipment. Instead, EPCA grants DOE clear authority to establish energy conservation standards for covered products and equipment.

PHCC asks for clarification as to why emissions information is presented at the 3 percent discount rate and not at 7 percent, stating that DOE should plainly state its rational for this practice other than not having a "single central SC-GHG point estimate" and that DOE should acknowledge that the projected social benefits and health benefits are not simple benefits to a purchase of CWH products but rather are benefits for the world population. (PHCC, No. 28 at p. 11) DOE discusses the global nature of social emissions benefits in sections I.C, IV.L.1.a, V.B.8, 0, and V.C.2. DOE uses all four sets of SC-GHG estimates to capture the uncertainties involved in regulatory impact analysis as recommended by the IWG. The rationale for the choice of discount rates is described in the IWG's February 2021 TSD.

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.8 of this document.

a. Social Cost of Carbon

The SC-CO_2 values used for this final rule were generated using the values presented in the 2021 update from the IWG's February 2021 TSD. Table IV.36 shows the updated sets of SC-CO_2 estimates from the IWG's TSD in 5-year increments from 2020 to 2050. The full set of annual values that DOE used is presented in appendix 14A of the final rule TSD. For purposes of capturing the uncertainties involved in regulatory impact analysis, DOE has determined it is appropriate to include all four sets of SC-CO_2 values, as recommended by the IWG.[172]

Table IV.36 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

172 For example, the February 2021 TSD discusses how the understanding of discounting approaches suggests that discount rates appropriate for intergenerational analysis in the context of climate change may be lower than 3 percent.

Year	Discount Rate and Statistic			
	5%	3%	2.5%	3%
	Average	Average	Average	95th percentile
2045	28	79	110	242
2050	32	85	116	260

In calculating the potential global benefits resulting from reduced CO_2 emissions, DOE used the values from the 2021 interagency report, adjusted to 2022$ using the implicit price deflator for gross domestic product ("GDP") from the Bureau of Economic Analysis. For each of the four sets of SC-CO_2 cases specified, the values for emissions in 2020 were $14, $51, $76, and $152 per metric ton avoided (values expressed in 2020$). For 2051 to 2070, DOE used SC-CO_2 estimates published by EPA, adjusted to 2022$.[173] These estimates are based on methods, assumptions, and parameters identical to the 2020–2050 estimates published by the IWG (which were based on EPA modeling). DOE expects additional climate benefits to accrue for any longer-life furnaces 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.

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 GDP from the Bureau of Economic Analysis. To calculate a present value of the stream of monetary values, DOE discounted the values in

[173] 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 January 13, 2023).

each of the four cases using the specific discount rate that had been used to obtain the $SC\text{-}CO_2$ values in each case. See appendix 14A for the annual $SC\text{-}CO_2$ values.

b. Social Cost of Methane and Nitrous Oxide

The $SC\text{-}CH_4$ and $SC\text{-}N_2O$ values used for this final rule were based on the values developed for the February 2021 TSD. Table IV.37 shows the updated sets of $SC\text{-}CH_4$ 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 $SC\text{-}CH_4$ and SC- N_2O values, as recommended by the IWG. DOE derived values after 2050 using the approach described above for the $SC\text{-}CO_2$.

Table IV.37 Annual $SC\text{-}CH_4$ and $SC\text{-}N_2O$ Values from 2021 Interagency Update, 2020–2050 (2020$ per Metric Ton)

Year	SC-CH4				SC-N2O			
	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 $SC\text{-}CH_4$ and $SC\text{-}N_2O$ estimates for that year in each of the cases. DOE adjusted the values to 2022$ using the implicit price deflator for 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. See chapter 13 for the annual emissions reduction. See appendix 14A for the annual SC-CH_4 and SC-N_2O values.

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.[174] DOE used EPA's values for PM2.5-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 benefit per ton estimates with regional information on electricity consumption and emissions to define weighted-average national values for NO_X and SO_2 as a function of sector (see appendix 14B of the NOPR TSD)..

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.

[174] *Estimating the Benefit per Ton of Reducing PM2.5 Precursors from 21 Sectors. www.epa.gov/benmap/estimating-benefit-ton-reducing-pm25-precursors-21-sectors.*

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. Details of the methodology are provided in the appendices to chapters 13 and 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.

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, their suppliers, and related service firms. 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.[175] 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

[175] See U.S. Department of Commerce–Bureau of Economic Analysis. *Regional Multipliers: A User Handbook for the Regional Input-Output Modeling System ("RIMS II")*. 1997. U.S. Government Printing Office: Washington, DC. Available at *www.bea.gov/scb/pdf/regional/perinc/meth/rims2.pdf* (last accessed July 1, 2021).

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 Impact of Sector Energy Technologies ("ImSET").[176] 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 understands the 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 (2026–2030), where these uncertainties are reduced. For more details on the employment impact analysis, see chapter 16 of the final rule TSD.

[176] 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.

V. Analytical Results and Conclusions

The following section addresses the results from DOE's analyses with respect to the considered energy conservation standards for CWH equipment. It addresses the TSLs examined by DOE, the projected impacts of each of these levels if adopted as energy conservation standards for CWH equipment, and the standards levels that 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 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 equipment classes, to the extent that there are such interactions, and market cross elasticity from consumer purchasing decisions that may change when different standard levels are set.

In the analysis conducted for this final rule, for commercial gas-fired storage water heaters, DOE included efficiency levels for both thermal efficiency and standby loss in each TSL because standby loss is dependent upon thermal efficiency. This dependence of standby loss on thermal efficiency is discussed in detail in section IIIIV.C.4.b of this final rule and chapter 5 of the final rule TSD. However, as discussed in section IV.C.4.b of this final rule, for all thermal efficiency levels for commercial gas-fired storage water heaters, DOE only analyzed one standby loss level corresponding to each thermal efficiency level.

The thermal efficiency levels for commercial gas-fired storage water heaters and commercial gas-fired instantaneous water heaters and hot water supply boilers, the standby loss levels for commercial gas-fired storage water heaters, and the UEF levels for residential-duty gas-fired storage water heaters that are included in each TSL are described in the following paragraphs and presented in Table V.1 of this final rule.

TSL 4 consists of the max-tech efficiency levels for each equipment category, which correspond to the highest condensing efficiency levels. TSL 3 consists of intermediate condensing efficiency levels for commercial gas-fired storage water heaters and residential-duty gas-fired storage water heaters, and max-tech efficiency levels for commercial gas-fired instantaneous water heaters and hot water supply boilers. TSL 2 consists of the minimum condensing efficiency levels analyzed for commercial gas-fired storage water heaters and residential-duty gas-fired storage water heaters, and intermediate condensing efficiency levels for commercial gas-fired instantaneous water heaters and hot water supply boilers. These TSLs require similar technologies to achieve the efficiency levels and have roughly comparable equipment availability across each equipment category in terms of the share of models available that meet the efficiency level and having multiple manufacturers that produce those models. TSL 1 consists of the maximum non-condensing thermal efficiency or UEF (as applicable) levels analyzed for each equipment category.

Table V.1 presents the efficiency levels for each equipment category (*i.e.*, commercial gas-fired storage water heaters and storage-type instantaneous water heaters, residential-duty gas-fired storage water heaters, gas-fired tankless water heaters, and gas-fired circulating water heaters and hot water supply boilers) in each TSL. Table V.2 presents the thermal efficiency value and standby loss reduction factor for each equipment category in each TSL that DOE considered, with the exception of residential-duty gas-fired storage water heaters (for which TSLs are shown separately in Table V.3). The standby loss reduction factor is a multiplier representing the reduction in allowed standby loss relative to the current standby loss standard and which corresponds to the associated increase in thermal efficiency. Table V.3 presents the UEF equations for residential-duty gas-fired storage water heaters corresponding to each TSL that DOE considered.

Table V.1 Trial Standard Levels for CWH Equipment by Efficiency Level

Equipment		Trial Standard Level*,**							
		1		2		3		4	
		E_t or UEF EL	SL EL	E_t or UEF EL	SL EL	E_t or UEF EL	SL EL	E_t or UEF EL	SL EL
Commercial gas-fired storage water heaters and storage-type instantaneous water heaters		1	0	2	0	4	0	5	0
Residential-duty gas-fired storage water heaters		2	-	3	-	4	-	5	-
Gas-fired instantaneous water heaters and hot water supply boilers	Tankless water heaters	2	-	4	-	5	-	5	-
	Circulating water heaters and hot water supply boilers	2	-	4	-	5	-	5	-

* E_t stands for thermal efficiency, SL stands for standby loss, UEF stands for uniform energy factor, and EL stands for efficiency level. E_t applies to commercial gas-fired storage water heaters and storage-type instantaneous water heaters, and to gas-fired instantaneous water heaters and hot water supply boilers. SL applies to commercial gas-fired storage water heaters and storage-type instantaneous water heaters. UEF applies to residential-duty gas-fired storage water heaters.
** As discussed in sections III.B.5 and III.B.6 of this final rule, DOE did not analyze amended standby loss standards for instantaneous water heaters and hot water supply boilers. In addition, standby loss standards are not applicable for residential-duty commercial gas-fired storage water heaters. Lastly, for commercial gas-fired storage water heaters and storage-type instantaneous water heaters DOE only analyzed the reduction that is inherent to increasing E_t and did not analyze SL efficiency levels above EL0.

Table V.2 Trial Standard Levels for CWH Equipment by Thermal Efficiency and Standby Loss Reduction Factor (Except Residential-Duty Gas-Fired Storage Water Heaters)

Equipment		Trial Standard Level*,**							
		1		2		3		4	
		E_t	SL Factor†	E_t	SL Factor†	E_t	SL Factor†	E_t	SL Factor†
Commercial gas-fired storage water heaters and storage-type instantaneous water heaters		82%	0.98	90%	0.91	95%	0.86	99%	0.83
Gas-fired instantaneous water heaters and hot water supply boilers	Tankless water heaters	84%	-	94%	-	96%	-	96%	-
	Circulating water heaters and hot water supply boilers	84%	-	94%	-	96%	-	96%	-

* E_t stands for thermal efficiency, and SL stands for standby loss.
** As discussed in sections III.B.5 and III.B.6 of this final rule, DOE did not analyze amended standby loss standards for instantaneous water heaters and hot water supply boilers.
† Standby loss reduction factor is a factor that is multiplied by the current maximum standby loss equations for each equipment class, as applicable. DOE used reduction factors to develop the amended maximum standby loss equation

Equipment	Trial Standard Level*,**							
	1		2		3		4	
	E_t	SL Factor†	E_t	SL Factor†	E_t	SL Factor†	E_t	SL Factor†

for each TSL. These reduction factors and maximum standby loss equations are discussed in section IV.C.4.b of this final rule.

Table V.3 Trial Standard Levels by UEF for Residential-Duty Gas-Fired Storage Water Heaters

Draw Pattern*	Trial Standard Level**			
	1	2	3	4
	UEF	UEF	UEF	UEF
High	0.7497-0.0009*Vr	0.8397-0.0009*Vr	0.9297-0.0009*Vr	0.9997-0.0009*Vr
Medium	0.6902-0.0011*Vr	0.7802-0.0011*Vr	0.8702-0.0011*Vr	0.9402-0.0011*Vr
Low	0.6262-0.0012*Vr	0.7162-0.0012*Vr	0.8062-0.0012*Vr	0.8762-0.0012*Vr
Very Small	0.3574-0.0009*Vr	0.4474-0.0009*Vr	0.5374-0.0009*Vr	0.6074-0.0009*Vr

* Draw pattern is a classification of hot water use of a consumer water heater or residential-duty commercial water heater, based upon the first-hour rating. The draw pattern is determined using the Uniform Test Method for Measuring the Energy Consumption of Water Heaters in in appendix E to subpart B of 10 CFR part 430.
** Vr is rated volume in gallons.

DOE constructed the TSLs for this final rule to include efficiency levels representative of efficiency levels with similar characteristics (*i.e.*, using similar technologies and/or efficiencies, and having roughly comparable equipment availability). The use of representative efficiency levels provided for greater distinction between the TSLs. While representative efficiency levels were included in the TSLs, DOE considered all efficiency levels as part of its analysis.[177]

[177] Efficiency levels that were analyzed for this final rule are discussed in section IV.C.4 of this document. Results by efficiency level are presented in TSD chapters 8, 10, and 12.

B. Economic Justification and Energy Savings

1. Economic Impacts on Individual Consumers

DOE analyzed the economic impacts on CWH equipment consumers by looking at the effects that potential 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.4 through Table V.13 of this final rule show the LCC and PBP results for the TSLs considered in this final rule. In the first of each pair of tables, the simple payback is measured relative to the baseline product. In the second table, impacts are measured relative to the efficiency distribution in the no-new-standards case in the compliance year (see section IV.F.8 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. As was noted in IV.H.1 of this document, DOE assumes a large percentage of consumers will already be purchasing higher efficiency condensing equipment by 2026. 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.4 Average LCC and PBP Results for Commercial Gas-Fired Storage Water Heaters and Storage-type Instantaneous Water Heaters

TSL*	Thermal Efficiency (E_t)	Standby Loss (SL) Factor	Average Costs *2022$*				Simple Payback Period *Years*
			Installed Cost	First Year's Operating Cost	Lifetime Operating Cost	LCC	
0	80%	1.00	6,083	2,419	18,589	24,672	0
1	82%	0.98	6,158	2,374	18,252	24,410	1.7
2	90%	0.91	7,477	2,243	17,266	24,743	7.9
3	95%	0.86	7,593	2,157	16,681	24,274	5.8
4	99%	0.83	7,733	2,094	16,206	23,939	5.1

* The results for each TSL are calculated assuming that all consumers use equipment with that efficiency level. The PBP is measured relative to the baseline equipment.
Note: TSL 0 represents the baseline.

Table V.5 Average LCC Savings Relative to the No-New-Standards Case for Commercial Gas-Fired Storage Water Heaters and Storage-type Instantaneous Water Heaters

TSL	Thermal Efficiency (E_t) Level	Standby Loss (SL) Factor	Life-Cycle Cost Savings		
			Percentage of Commercial Consumers That Experience a Net Cost	Percentage of Commercial Consumers That Experience a Net Benefit	Average Life-Cycle Cost Savings* *2022$*
0	80%	1.00	0%	0%	0
1	82%	0.98	3%	32%	267
2	90%	0.91	19%	18%	(85)
3	95%	0.86	17%	35%	367
4	99%	0.83	23%	76%	528

* The calculation includes affected consumers only. A value in parenthesis is a negative number.
Note: TSL 0 represents the baseline.

Table V.6 Average LCC and PBP Results for Residential-Duty Gas-Fired Storage Water Heaters

TSL*	UEF**	Average Costs *2022$*				Simple Payback Period *years*
		Installed Cost	First Year's Operating Cost	Lifetime Operating Cost	LCC	
0	0.59	2,539	1,519	13,470	16,009	
1	0.68	2,791	1,427	12,671	15,462	2.7
2	0.77	3,746	1,365	12,220	15,966	7.8
3	0.86	4,135	1,298	11,634	15,769	7.2
4	0.93	4,199	1,261	11,311	15,510	6.4

* The results for each TSL are calculated assuming that all consumers use equipment with that efficiency level. The PBP is measured relative to the baseline equipment.
Note: TSL 0 represents the baseline.
** The UEF shown is for the representative capacity of 75 gallons.

Table V.7 Average LCC Savings Relative to the No-New-Standards Case for Residential-Duty Gas-Fired Storage Water Heaters

TSL	UEF*	Life-Cycle Cost Savings		
		Percentage of Commercial Consumers That Experience a Net Cost	Percentage of Commercial Consumers That Experience a Net Benefit	Average Life-Cycle Cost Savings** *2022$*
0	0.59	0%	0%	0
1	0.68	6%	69%	509
2	0.77	43%	47%	(80)
3	0.86	42%	50%	119
4	0.93	37%	62%	370

* The UEF shown is for the representative capacity of 75 gallons.
** The calculation includes affected consumers only. A value in parentheses is a negative number.
Note: TSL 0 represents the baseline.

Table V.8 Average LCC and PBP Results by Efficiency Level for Gas-Fired Tankless Water Heaters

TSL*	Thermal Efficiency (E_t)	Average Costs *2022$*				Simple Payback Period *years*
		Installed Cost	First Year's Operating Cost	Lifetime Operating Cost	LCC	
0	80%	3,007	821	9,535	12,543	
1	84%	3,046	789	9,201	12,247	1.3
2	94%	3,858	729	8,612	12,471	9.3
3	96%	3,925	717	8,480	12,405	8.9
4	96%	3,925	717	8,480	12,405	8.9

* The results for each TSL are calculated assuming that all consumers use equipment with that efficiency level. The PBP is measured relative to the baseline equipment.
TSL 0 represents the baseline.

Table V.9 Average LCC Savings Relative to the No-New-Standards-Case Efficiency Distribution for Gas-Fired Tankless Water Heaters

TSL	Thermal Efficiency (E_t)	Life-Cycle Cost Savings		
		Percentage of Commercial Consumers that Experience a Net Cost	Percentage of Commercial Consumers that Experience a Net Benefit	Average Life-Cycle Cost Savings* *2022$*
0	80%	0%	0%	0
1	84%	0%	17%	295
2	94%	10%	11%	105
3	96%	15%	27%	120
4	96%	15%	27%	120

* The calculation includes affected consumers only.
Note: TSL 0 represents the baseline.

Table V.10 Average LCC and PBP Results by Efficiency Level for Gas-Fired Circulating Water Heaters and Hot Water Supply Boilers

TSL*	Thermal Efficiency (E_t)	Average Costs *2022$*				Simple Payback Period *Years*
		Installed Cost	First Year's Operating Cost	Lifetime Operating Cost	LCC	
0	80%	8,622	5,273	80,367	88,989	
1	84%	8,830	5,114	77,996	86,826	1.3
2	94%	13,973	4,731	72,358	86,331	9.9
3	96%	14,362	4,661	71,307	85,668	9.4
4	96%	14,362	4,661	71,307	85,668	9.4

* The results for each TSL are calculated assuming that all consumers use equipment with that efficiency level. The PBP is measured relative to the baseline equipment.
Note: TSL 0 represents the baseline.

Table V.11 Average LCC Savings Relative to the No-New-Standards-Case Efficiency Distribution for Gas-Fired Circulating Water Heaters and Hot Water Supply Boilers

TSL	Thermal Efficiency (E_t)	Life-Cycle Cost Savings		
		Percentage of Commercial Consumers that Experience a Net Cost	Percentage of Commercial Consumers that Experience a Net Benefit	Average Life-Cycle Cost Savings* *2022$*
0	80%	0%	0%	0
1	84%	2%	17%	1,153
2	94%	17%	16%	1,204
3	96%	18%	26%	1,570
4	96%	18%	26%	1,570

* The calculation includes affected consumers only.
Note: TSL 0 represents the baseline.

Table V.12 Average LCC and PBP Results by Efficiency Level for Gas-Fired Instantaneous Water Heaters and Hot Water Supply Boilers*

TSL **	Thermal Efficiency (E_t)	Average Costs 2022$				Simple Payback Period *Years*
		Installed Cost	First Year's Operating Cost	Lifetime Operating Cost	LCC	
0	80%	6,021	3,211	47,561	53,582	
1	84%	6,151	3,111	46,132	52,284	1.3
2	94%	9,288	2,877	42,834	52,122	9.8
3	96%	9,528	2,834	42,208	51,736	9.3
4	96%	9,528	2,834	42,208	51,736	9.3

* This table shows results for the gas-fired instantaneous water heaters and hot water supply boilers equipment class (*i.e.*, both tankless water heaters and hot water supply boilers), and reflects a weighted average result of Tables V.8 and V.10 of this final rule.
** The results for each TSL are calculated assuming that all consumers use equipment with that efficiency level. The PBP is measured relative to the baseline equipment.
Note: TSL 0 represents the baseline.

Table V.13 Average LCC Savings Relative to the No-New-Standards-Case Efficiency Distribution for Gas-Fired Instantaneous Water Heaters and Hot Water Supply Boilers*

TSL	Thermal Efficiency (E_t)	Life-Cycle Cost Savings		
		Percentage of Commercial Consumers that Experience a Net Cost	Percentage of Commercial Consumers that Experience a Net Benefit	Average Life-Cycle Cost Savings** *2022$*
0	80%	0%	0%	0
1	84%	1%	17%	756
2	94%	14%	14%	695
3	96%	17%	27%	898
4	96%	17%	27%	898

* This table shows results for the gas-fired instantaneous water heaters and hot water supply boilers equipment class (*i.e.*, both tankless water heaters and hot water supply boilers), and reflects a weighted average result of Tables V.9 and V.11 of this final rule.
** The calculation includes affected consumers only.
Note: TSL 0 represents the baseline.

b. Consumer Subgroup Analysis

In the consumer subgroup analysis, DOE estimated the impact of the considered TSLs on a low-income residential population (0–20 percentile gross annual household income) subgroup. Table V.14 through Table V.23 of this final rule compare the average LCC savings and PBP at each efficiency level for the consumer subgroup, along with the average LCC savings for the entire consumer sample. In most cases, the average LCC savings and PBP for low-income residential consumers at the considered efficiency levels are either similar to or more favorable than the average for all consumers, due in part to greater levels of equipment usage in RECS apartment building sample identified as low-income observations when compared to the average consumer of CWH equipment. Chapter 11 of the final rule TSD presents the complete LCC and PBP results for the subgroup analysis.

Table V.14 Comparison of Impacts for Consumer Subgroup with All Consumers, Commercial Gas-Fired Storage Water Heaters and Storage-type Instantaneous Water Heaters

TSL	Thermal Efficiency (E_t)	Standby Loss (SL) Factor	LCC Savings *2022$*		Simple Payback Period *years*	
			Residential Low-Income	All	Residential Low-Income	All
1	82%	98%	524	267	1.0	1.7
2	90%	91%	994	(85)	4.3	7.9
3	95%	86%	1,578	367	3.2	5.8
4	99%	83%	1,542	528	2.8	5.1

Table V.15 Comparison of Impacted Consumers for Consumer Subgroup and All Consumers, Commercial Gas-Fired Storage Water Heaters and Storage-type Instantaneous Water Heaters

TSL	Thermal Efficiency (E_t)	Standby Loss (SL) Factor	Percent of Consumers that Experience a Net Cost		Percent of Consumers that Experience a Net Benefit	
			Residential Low-Income	All	Residential Low-Income	All
1	82%	98%	0%	3%	34%	32%
2	90%	91%	10%	19%	27%	18%
3	95%	86%	6%	17%	46%	35%
4	99%	83%	4%	23%	95%	76%

Table V.16 Comparison of Impacts for Consumer Subgroup with All Consumers, Residential-Duty Gas-Fired Storage Water Heaters

TSL	UEF	LCC Savings *2022$*		Simple Payback Period *Years*	
		Residential Low-Income	All	Residential Low-Income	All
1	0.68	716	509	2.2	2.7
2	0.77	368	(80)	5.6	7.8
3	0.86	729	119	5.3	7.2
4	0.93	1,033	370	4.7	6.4

* Parentheses indicate negative values.

Table V.17 Comparison of Impacted Consumers for Consumer Subgroup and All Consumers, Residential-Duty Gas-Fired Storage Water Heaters

TSL	UEF	Percent of Consumers that Experience a Net Cost		Percent of Consumers that Experience a Net Benefit	
		Residential Low-Income	All	Residential Low-Income	All
1	0.68	1%	6%	73%	69%
2	0.77	28%	43%	61%	47%
3	0.86	24%	42%	68%	50%
4	0.93	19%	37%	79%	62%

Table V.18 Comparison of Impacts for Consumer Subgroup with All Consumers, Gas-Fired Tankless Water Heaters

TSL	Thermal Efficiency (E_t)	LCC Savings *2022$*		Simple Payback Period *years*	
		Residential Low-Income	All	Residential Low-Income	All
1	84%	217	295	1.7	1.3
2	94%	26	105	10.2	9.3
3	96%	49	120	9.9	8.9
4	96%	49	120	9.9	8.9

Table V.19 Comparison of Impacted Consumers for Consumer Subgroup and All Consumers, Gas-Fired Tankless Water Heaters

TSL	Thermal Efficiency (E_t)	Percent of Consumers that Experience a Net Cost		Percent of Consumers that Experience a Net Benefit	
		Residential Low-Income	All	Residential Low-Income	All
1	84%	0%	0%	17%	17%
2	94%	11%	10%	10%	11%
3	96%	17%	15%	26%	27%
4	96%	17%	15%	26%	27%

Table V.20 Comparison of Impacts for Consumer Subgroup with All Consumers, Gas-Fired Circulating Water Heaters and Hot Water Supply Boilers

TSL	Thermal Efficiency (E_t)	LCC Savings *2022$*		Simple Payback Period *years*	
		Residential Low-Income	All	Residential Low-Income	All
1	84%	2,289	1,153	0.7	1.3
2	94%	7,552	1,204	5.6	9.9
3	96%	7,425	1,570	5.3	9.4
4	96%	7,425	1,570	5.3	9.4

Table V.21 Comparison of Impacted Consumers for Consumer Subgroup and All Consumers, Gas-Fired Circulating Water Heaters and Hot Water Supply Boilers

TSL	Thermal Efficiency (E_t)	Percent of Consumers that Experience a Net Cost		Percent of Consumers that Experience a Net Benefit	
		Residential Low-Income	All	Residential Low-Income	All
1	84%	0%	2%	19%	17%
2	94%	5%	17%	28%	16%
3	96%	5%	18%	40%	26%
4	96%	5%	18%	40%	26%

Table V.22 Comparison of Impacts for Consumer Subgroup with All Consumers, Gas-Fired Instantaneous Water Heaters and Hot Water Supply Boilers*

TSL	Thermal Efficiency (E_t)	LCC Savings *2022$*		Simple Payback Period *Years*	
		Residential Low-Income	All	Residential Low-Income	All
1	84%	1,329	756	0.8	1.3
2	94%	4,066	695	5.8	9.8
3	96%	4,009	898	5.5	9.3
4	96%	4,009	898	5.5	9.3

* This table shows results for the gas-fired instantaneous water heaters and hot water supply boilers equipment class (*i.e.*, both tankless water heaters and hot water supply boilers), and reflects a weighted average result of Tables V.18 and V.20 of this final rule.

Table V.23 Comparison of Impacted Consumers for Consumer Subgroup and All Consumers, Gas-Fired Instantaneous Water Heaters and Hot Water Supply Boilers*

TSL	Thermal Efficiency (E_t)	Percent of Consumers that Experience a Net Cost		Percent of Consumers that Experience a Net Benefit	
		Residential Low-Income	All	Residential Low-Income	All
1	84%	0%	1%	18%	17%
2	94%	8%	14%	20%	14%
3	96%	10%	17%	33%	27%
4	96%	10%	17%	33%	27%

* This table shows results for the gas-fired instantaneous water heaters and hot water supply boilers equipment class (*i.e.*, both tankless water heaters and hot water supply boilers), and reflects a weighted average result of Tables V.19 and V.21 of this final rule.

c. Rebuttable Presumption Payback

As discussed in section II.A, 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 PBP 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 CWH equipment. 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.24 presents the rebuttable presumption PBPs for the considered TSLs for CWH equipment. TSL 1 is the only level at which the rebuttable presumption PBPs are less than or equal to three. See chapter 8 of the final rule TSD for more information on the rebuttable presumption PBP analysis.

Table V.24 Rebuttable Presumption Payback Periods

Equipment	Trial Standard Level			
	1	2	3	4
	Years			
Commercial Gas-Fired Storage and Storage-Type Instantaneous Water Heaters	1.7	7.5	5.6	5.0
Residential-Duty Gas-Fired Storage	2.7	7.6	7.1	6.3
Gas-Fired Instantaneous Water Heaters and Hot Water Supply Boilers*	1.3	9.5	9.1	9.1
Instantaneous, Gas-Fired Tankless	1.3	8.7	8.4	8.4
Instantaneous Water Heaters and Hot Water Supply Boilers	1.3	9.6	9.1	9.1

* This row shows results for the gas-fired instantaneous water heaters and hot water supply boilers equipment class (*i.e.*, both tankless water heaters and hot water supply boilers), and reflects a weighted average result.

2. Economic Impacts on Manufacturers

DOE performed an MIA to estimate the impact of amended energy conservation standards on manufacturers of CWH equipment. 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. Table V.25 through Table V.28 of this final rule summarize the estimated financial impacts of potential amended energy conservation standards on manufacturers of CWH equipment, as well as the conversion costs that DOE estimates manufacturers of CWH equipment would incur at each TSL.

The impact of potential amended energy conservation standards was analyzed under two markup scenarios: (1) the preservation of gross margin percentage markup scenario and (2) the preservation of per-unit operating profit markup scenario, as discussed in section IV.J.2.d of this document. The preservation of gross margin percentage scenario provides the upper bound while the preservation of operating profits scenario results in the lower (or more severe) bound to impacts of potential amended standards on industry.

Each of the modeled scenarios results in a unique set of cash flows and corresponding INPV for each TSL. INPV is the sum of the discounted cash flows to the industry from the base year through the end of the analysis period (2023–2055). The "change in INPV" results refer to the difference in industry value between the no-new-standards case and standards case at each TSL. To provide perspective on the short-run cash flow impact, DOE includes a comparison of free cash flow between the no-new-standards case and the standards case at each TSL in the year before amended standards would take effect. This free cash flow comparison provides an understanding of the magnitude of the required conversion costs relative to the cash flow generated by the industry in the no-new-standards case.

Conversion costs are one-time investments for manufacturers to bring their manufacturing facilities and product designs into compliance with potential amended standards. As described in section IV.J.2.c of this document, conversion cost 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 costs can have a significant impact on the short-term cash flow on the industry and generally result in lower free cash flow in the period between the publication of the final rule and the compliance date of potential amended standards. Conversion costs are independent of the manufacturer markup scenarios and are not presented as a range in this analysis.

The results in Table V.25 through Table V.28 of this final rule show potential INPV impacts for CWH equipment manufacturers by equipment class. The tables present the range of potential impacts reflecting both the less severe set of potential impacts (preservation of gross margin) and the more severe set of potential impacts (preservation of per-unit operating profit). In the following discussion, the INPV results refer to the difference in industry value between the no-new-standards case and each standards case that results from the sum of discounted cash flows from 2023 (the base year) through 2055 (the end of the analysis period).

Industry Cash Flow for Commercial Gas-Fired Storage Water Heaters and Storage-Type Instantaneous Equipment

The results in Table V.25 of this final rule shows the estimated impacts for commercial gas-fired storage water heaters. Commercial gas-fired storage water heaters represent approximately 69 percent of shipments covered by this rulemaking.

Table V.25 Manufacturing Impact Analysis Results for Commercial Gas-Fired Storage Water Heaters and Storage-Type Instantaneous Water Heaters

	Units	No-New-Standards Case	Trial Standard Level			
			1	2	3	4
INPV	2022$ millions	154.2	153.3 - 154.0	139.1 - 142.7	130.4 - 136.5	62.0 - 73.1
Change in INPV	2022$ millions	-	(0.9) - (0.1)	(15.0) - (11.4)	(23.7) - (17.6)	(92.1) - (81.0)
	%	-	(0.6) - (0.1)	(9.7) - (7.4)	(15.4) - (11.4)	(59.8) - (52.6)
Free Cash Flow (2025)	2022$ millions	12.6	12.2	5.1	1.2	(34.4)
Change in Free Cash Flow	2022$ millions	-	(0.4)	(7.5)	(11.5)	(47.1)
	%	-	(3.1)	(59.3)	(90.6)	(372.3)
Product Conversion Costs	*2022$ millions*	-	1.0	4.9	10.9	84.1
Capital Conversion Costs	*2022$ millions*	-	0.1	12.8	16.9	28.1
Total Conversion Costs	*2022$ millions*	-	1.1	17.7	27.8	112.2

At TSL 1, DOE estimates impacts on INPV for commercial gas-fired storage and storage-type instantaneous water heater equipment manufacturers to range from -0.6 percent to -0.1 percent, or a change of -$0.9 million to -$0.1 million. At this level, DOE estimates that industry free cash flow would decrease by approximately 3.1 percent to $12.2 million, compared to the no-new-standards-case value of $12.6 million in the year before compliance (2025).

DOE estimates 67.3 percent of commercial gas-fired storage water heater and storage-type instantaneous water heater basic models meet or exceed the thermal efficiency and standby loss standards at TSL 1. DOE does not expect the modest increases in thermal efficiency and standby loss requirements at this TSL to require major equipment redesigns or large capital investments. Overall, DOE estimates that manufacturers would incur $1.0 million in product conversion costs and $0.1 million in capital conversion costs to bring their equipment portfolios into compliance with a standard set to TSL 1. At TSL 1, conversion costs are a key driver of results. These upfront investments result in a slightly lower INPV in both manufacturer markup scenarios.

At TSL 2, DOE estimates impacts on INPV for manufacturers of this equipment class to range from -9.7 percent to -7.4 percent, or a change in INPV of -$15.0 million to -$11.4 million. At this potential standard level, industry free cash flow would decrease by approximately 59.3 percent to $5.1 million, compared to the no-new-standards case value of $12.6 million in the year before compliance (2025).

DOE estimates 41 percent of commercial gas-fired storage water heater and storage-type instantaneous water heater basic models meet or exceed the thermal efficiency and standby loss standards at TSL 2. Product and capital conversion costs would increase at this TSL as manufacturers update designs, production equipment, and floor space to meet a thermal efficiency standard that necessitates condensing technology. DOE notes that capital investment would vary by manufacturer due to differences in condensing heat exchanger designs and differences in existing production capacity. These capital conversion costs include, but are not limited to, investments in tube bending, press dies, machining, enameling, MIG welding, leak testing, quality assurance stations, and conveyer.

DOE estimates that industry would incur $4.9 million in product conversion costs and $12.8 million in capital conversion costs to bring their offered commercial gas-fired storage water heaters and storage-type instantaneous water heaters into compliance with a standard set to TSL 2. At TSL 2, conversion costs are a key driver of results. These upfront investments result in a lower INPV in both manufacturer markup scenarios.

At TSL 3, DOE estimates impacts on INPV for commercial gas-fired storage water heater and storage-type instantaneous water heater manufacturers to range from -15.4 percent to -11.4 percent, or a change in INPV of -$23.7 million to -$17.6 million. At this potential standard level, DOE estimates industry free cash flow would decrease by approximately 90.6 percent to $1.2 million, compared to the no-new-standards-case value of $12.6 million in the year before compliance (2025).

DOE estimates that 34 percent of currently offered commercial gas-fired storage water heater and storage-type instantaneous water heater basic models meet or exceed the thermal efficiency and standby loss standards at TSL 3. At this level, DOE estimates that product conversion costs would increase, as manufacturers would have to redesign a larger percentage of their offerings to meet the higher thermal efficiency levels. Additionally, capital conversion costs would increase, as manufacturers upgrade their laboratories and test facilities to increase capacity for product development and safety testing for their commercial gas-fired storage water heater and storage-type instantaneous water heater offerings. Overall, DOE estimates that manufacturers would incur $10.9 million in product conversion costs and $16.9 million in capital conversion costs to bring their commercial gas-fired storage water heater and storage-type instantaneous water heater portfolio into compliance with a standard set to TSL 3. At TSL 3, conversion costs are a key driver of results. These upfront investments result in lower INPV in both manufacturer markup scenarios.

TSL 4 represents the max-tech thermal efficiency and standby loss levels. At TSL 4, DOE estimates impacts on INPV for commercial gas-fired storage water heater and storage-type instantaneous water heater manufacturers to range from -59.8 percent to -52.6 percent, or a change in INPV of -$92.1 million to -$81.0 million. At this TSL, DOE estimates industry free cash flow in the year before compliance (2025) would decrease by approximately 372.3 percent to -$34.4 million compared to the no-new-standards case value of $12.6 million.

The impacts on INPV at TSL 4 are significant. DOE estimates less than 1 percent of currently offered basic models meet or exceed the efficiency levels prescribed at TSL 4. DOE expects product conversion costs to be significant at TSL 4, as almost all equipment on the market would have to be redesigned. Furthermore, the redesign process would be more resource intensive and costly at TSL 4 than at other TSLs. Traditionally, manufacturers design their equipment platforms to support a range of models with varying input capacities and storage volumes, and the efficiency typically will vary slightly between models within a given platform. However, at TSL 4, manufacturers would be limited in their ability to maintain a platform approach to designing commercial gas-fired storage and storage-type instantaneous water heaters, because the 99 percent thermal efficiency level represents the maximum achievable efficiency and there would be no allowance for slight variations in efficiency between individual models. At TSL 4, manufacturers would be required to separately redesign each individual model to optimize performance for each specific input capacity and storage volume combination. In manufacturer interviews, some manufacturers raised concerns that they would not have sufficient engineering capacity to complete necessary redesigns within the 3-year conversion period. If manufacturers require more than 3 years to redesign all models, they would likely prioritize redesigns based on sales volume. Due to the increase in number of redesigns and engineering effort, DOE estimates that product conversion costs would increase to $84.1 million.

DOE estimates that manufacturers would also incur $28.1 million in capital conversion costs. In addition to upgrading production lines, DOE expects manufacturers would need to add laboratory space to develop and test products to meet amended standards at TSL 4 standards. These large upfront investments result in a substantially lower INPV in both manufacturer markup scenarios.

At TSL 4, the large conversion costs result in a free cash flow dropping below zero in the years before the standard year. The negative free cash flow calculation indicates manufacturers may need to access cash reserves or outside capital to finance conversion efforts.

Industry Cash Flow for Residential-Duty Gas-Fired Storage Water Heaters

The results in Table V.26 of this final rule shows the estimated impacts for residential-duty gas-fired storage water heaters. Residential-duty gas-fired storage water heaters represent approximately 13.5 percent of shipments covered by this rulemaking.

Table V.26 Manufacturing Impact Analysis Results for Residential-Duty Gas-Fired Storage Water Heaters

	Units	No-New-Standards Case	Trial Standard Level			
			1	2	3	4
INPV	*2022$ millions*	9.0	8.4 - 9.6	7.6 - 9.6	6.5 - 11.2	2.3 - 7.4
Change in INPV	*2022$ millions*	-	(0.5) - 0.6	(1.4) - 0.7	(2.5) - 2.2	(6.7) - (1.5)
	%	-	(5.8) - 6.8	(15.3) - 7.4	(27.3) - 25.0	(74.7) - (16.9)
Free Cash Flow (2025)	*2022$ millions*	0.7	0.5	0.2	(0.2)	(2.4)
Change in Free Cash Flow	*2022$ millions*	-	(0.2)	(0.6)	(0.9)	(3.1)
	%	-	(26.9)	(78.8)	(125.6)	(429.9)
Product Conversion Costs	*2022$ millions*	-	0.5	0.8	1.2	4.8
Capital Conversion Costs	*2022$ millions*	-	0.1	0.7	1.0	2.5
Total Conversion Costs*	*2022$ millions*	-	0.5	1.4	2.3	7.3

*Product conversion costs + capital conversion costs = total conversion costs. Numbers may not add up exactly due to rounding.

At TSL 1, DOE estimates impacts on INPV for residential-duty gas-fired storage equipment manufacturers to range from -5.8 percent to 6.8 percent, or a change of -$0.5 million to $0.6 million. At this level, DOE estimates that industry free cash flow would decrease by approximately 26.9 percent to $0.5 million, compared to the no-new-standards-case value of $0.7 million in the year before compliance (2025).

DOE estimates that 50 percent of currently offered residential-duty gas-fired storage water heater basic models already meet or exceed the UEF standards at TSL 1. DOE does not expect the modest increases in UEF requirements at this TSL to require major equipment redesigns or large capital investments. Overall, DOE estimates that industry would incur $0.5 million in product conversion costs and $0.1 million in capital conversion costs to bring their residential-duty commercial gas-fired storage equipment portfolios into compliance with a standard set to TSL 1. At TSL 1, conversion costs are the primary driver of results. These upfront investments result in a moderately lower INPV for the preservation of operating profit scenario and a moderately higher INPV for the preservation of gross margin scenario.

At TSL 2, DOE estimates impacts on INPV for manufacturers of this equipment class to range from -15.3 percent to 7.4 percent, or a change in INPV of -$1.4 million to $0.7 million. At this potential standard level, industry free cash flow would decrease by approximately 78.8 percent to $0.2 million, compared to the no-new-standards case value of $0.7 million in the year before compliance (2025).

DOE estimates that 32 percent of currently offered residential-duty gas-fired storage water heater basic models would already meet or exceed the UEF standards at TSL 2. Product and capital conversion costs would increase at this TSL. Manufacturers would meet the UEF levels for residential-duty commercial gas-fired storage equipment by shifting to condensing technology. DOE notes that the capital investment would vary by manufacturer due to differences in condensing heat exchanger designs and differences in existing production capacity.

DOE estimates that industry would incur $0.8 million in product conversion costs and $0.7 million in capital conversion costs to bring their residential-duty gas-fired storage water heaters into compliance with a standard set to TSL 2. At TSL 2, conversion costs continue to be the primary driver of results. These upfront investments result in a lower INPV in both manufacturer markup scenarios.

At TSL 3, DOE estimates impacts on INPV for residential-duty gas-fired manufacturers to range from -27.3 percent to 25.0 percent, or a change in INPV of -$2.5 million to $2.2 million. At this potential standard level, DOE estimates industry free cash flow would decrease by approximately 125.6 percent to -$0.2 million compared to the no-new-standards-case value of $0.7 million in the year before compliance (2025).

DOE estimates that 27 percent of currently offered residential-duty commercial gas-fired storage water heater basic models would meet or exceed the UEF standards at TSL 3. At this level, DOE estimates that product conversion costs would increase, as manufacturers would have to redesign a larger percentage of their offerings to meet the higher UEF levels and transition to a complete portfolio of condensing offerings. Additionally, capital conversion costs would increase, as manufacturers increase production capacity for condensing equipment. Overall, DOE estimates that manufacturers would incur $1.2 million in product conversion costs and $1.0 million in capital conversion costs to bring their residential-duty commercial gas-fired storage water heater portfolio into compliance with a standard set to TSL 3. At TSL 3, conversion costs are a key driver of results.

TSL 4 represents the max-tech UEF levels. At TSL 4, DOE estimates impacts on INPV for residential-duty commercial gas-fired storage water heater manufacturers to range from -74.7 percent to -16.9 percent, or a change in INPV of -$6.7 million to -$1.5 million. At this TSL, DOE estimates industry free cash flow in the year before compliance (2025) would decrease by approximately 429.9 percent to -$2.4 million compared to the no-new-standards case value of $0.7 million.

The impacts on INPV at TSL 4 are significant. DOE estimates that approximately 2 percent of currently offered residential-duty gas-fired water heater equipment meet or exceed the efficiency levels prescribed at TSL 4. DOE expects conversion costs to be significant at TSL 4, as most equipment currently on the market would have to be redesigned and new products would have to be developed to meet a wider range of storage volumes. DOE estimates that product conversion costs would increase to $4.8 million, as manufacturers would have to redesign a much larger percentage of their offerings to meet max-tech.

DOE estimates that manufacturers would also incur $2.5 million in capital conversion costs. In addition to upgrading production lines, DOE accounted for the costs to add laboratory space to develop and safety test products that meet max-tech efficiency levels. At TSL 4, conversion costs are high. These upfront investments result in a lower INPV in both manufacturer markup scenarios.

At TSL 4, the large conversion costs result in a free cash flow dropping below zero in the years before the standard year. The negative free cash flow calculation indicates manufacturers may need to access cash reserves or outside capital to finance conversion efforts.

Industry Cash Flow for Gas-Fired Instantaneous Tankless Water Heaters

The results in Table V.27 of this final rule shows the estimated impacts for gas-fired instantaneous tankless water heaters. Gas-fired instantaneous tankless water heaters represent approximately 8 percent of shipments covered by this rulemaking.

Table V.27 Manufacturing Impact Analysis Results for Gas-Fired Instantaneous Tankless Water Heaters

	Units	No-New-Standards Case	Trial Standard Level			
			1	2	3	4
INPV	*2022$ millions*	8.9	8.3 - 8.4	7.2 - 7.5	7.2 - 7.6	7.2 - 7.6
Change in INPV	*2022$ millions*	-	(0.5) - (0.5)	(1.7) - (1.4)	(1.7) - (1.3)	(1.7) - (1.3)
	%	-	(6.0) - (5.6)	(18.6) - (15.6)	(19.0) - (14.2)	(19.0) - (14.2)
Free Cash Flow (2025)	*2022$ millions*	0.6	0.3	(0.3)	(0.3)	(0.3)
Change in Free Cash Flow	*2022$ millions*	-	(0.3)	(0.8)	(0.8)	(0.8)
	%	-	(46.7)	(145.6)	(146.0)	(146.0)
Product Conversion Costs	*2022$ millions*	-	0.7	1.5	1.5	1.5
Capital Conversion Costs	*2022$ millions*	-	0.0	0.7	0.7	0.7
Total Conversion Costs*	*2022$ millions*	-	0.7	2.1	2.1	2.1

*Product conversion costs + capital conversion costs = total conversion costs. Numbers may not add up exactly due to rounding.

At TSL 1, DOE estimates impacts on INPV for gas-fired instantaneous tankless water heaters manufacturers to range from -6.0 percent to -5.6 percent, or a change of approximately -$0.53 million to -$0.50 million. At this level, DOE estimates that industry free cash flow would decrease by approximately -46.7 percent to $0.3 million, compared to the no-new-standards-case value of $0.6 million in the year before compliance (2025).

DOE estimates that 91 percent of basic models of gas-fired instantaneous tankless water heaters already meet or exceed the thermal efficiency standards at TSL 1. At this level, DOE expects manufacturers of this equipment class to incur product conversion costs to redesign their equipment. DOE does not expect the modest increases in thermal efficiency requirements at this TSL to require capital investments. Overall, DOE estimates that manufacturers would incur $0.7 million in product conversion costs and no capital conversion costs to bring this equipment portfolio into compliance with a standard set to TSL 1. At TSL 1, product conversion costs are the key driver of results. These upfront investments result in a lower INPV in both manufacturer markup scenarios.

At TSL 2, DOE estimates impacts on INPV ranges from -18.6 percent to -15.6 percent, or a change in INPV of -$1.7 million to -$1.4 million. At this potential standard level, DOE estimates industry free cash flow to decrease by approximately 145.6 percent to -$0.3 million compared to the no-new-standards-case value of $0.6 million in the year before compliance (2025).

DOE estimates that 86 percent of basic models of gas-fired instantaneous tankless water heaters already meet or exceed the thermal efficiency standards at TSL 2. DOE estimates that product and capital conversion costs would increase at this TSL. Manufacturers would meet the thermal efficiency levels by using condensing technology. DOE understands that tankless water heater manufacturers produce far more consumer products in significantly higher volumes than commercial offerings, and that these products are manufactured in the same facilities with shared production lines. DOE expects manufacturers would need to make incremental investments rather than set up new production lines. Overall, DOE estimates that manufacturers would incur $1.5 million in product conversion costs and $0.7 million in capital conversion costs to bring their instantaneous gas-fired tankless water heater portfolio into compliance with a standard set to TSL 2.

As discussed in section V.A, TSL 3 and TSL 4 represent max-tech thermal efficiency levels for gas-fired instantaneous tankless water heaters. Therefore, DOE modeled identical impacts to manufacturers of this equipment for both TSL 3 and TSL 4. At these levels, DOE estimates impacts on INPV to range from -19.0 percent to -14.2 percent, or a change in INPV of -$1.7 million to -$1.3 million. At these levels, DOE estimates industry free cash flow in the year before compliance (2025) would decrease by approximately 146.0 percent to -$0.3 million compared to the no-new-standards case value of $0.6 million. DOE estimates that 64 percent of basic models of gas-fired instantaneous tankless water heaters already meet or exceed the thermal efficiency standards at TSL 3 and TSL 4.

DOE anticipates modest product conversion costs as manufacturers continue to increase their max-tech offerings at greater input capacities. Overall, DOE estimates that manufacturers would incur $1.5 million in product conversion costs and $0.7 million in capital conversion costs to bring their gas-fired instantaneous tankless portfolio into compliance with a standard set to TSL 3 and TSL 4.

Industry Cash Flow for Instantaneous Circulating Water Heaters and Hot Water Supply Boilers

The results in Table V.28 show the estimated impacts for circulating water heaters and hot water supply boilers. This equipment represents approximately 9 percent of shipments covered by this rulemaking.

Table V.28 Manufacturing Impact Analysis Results for Circulating Water Heaters and Hot Water Supply Boilers

	Units	**No-New-Standards Case**	**Trial Standard Level**			
			1	**2**	**3**	**4**
INPV	*2022$ millions*	40.8	40.6 - 40.7	36.3 - 43.6	30.9 - 39.7	30.9 - 39.7
Change in INPV	*2022$ millions*	-	(0.2) - (0.0)	(4.4) - 2.8	(9.9) - (1.1)	(9.9) - (1.1)
	%	-	(0.5) - (0.1)	(10.9) - 7.0	(24.3) - (2.7)	(24.3) - (2.7)
Free Cash Flow (2025)	*2022$ millions*	2.5	2.4	0.9	(1.5)	(1.5)
Change in Free Cash Flow	*2022$ millions*	-	(0.1)	(1.6)	(4.1)	(4.1)
	%	-	(3.5)	(63.0)	(161.3)	(161.3)
Product Conversion Costs	*2022$ millions*	-	0.3	1.9	8.5	8.5
Capital Conversion Costs	*2022$ millions*	-	0.0	2.0	2.0	2.0
Total Conversion Costs	*2022$ millions*	-	0.3	3.9	10.5	10.5

At TSL 1, DOE estimates impacts on INPV for instantaneous circulating water heater and hot water supply boiler manufacturers to range from -0.2 percent to 0.1 percent, or a change of -$0.2 million to less than 0.1 million. At this level, DOE estimates that industry free cash flow would decrease by approximately 3.5 percent to

$2.4 million, compared to the no-new-standards-case value of $2.5 million in the year before compliance (2025).

DOE estimates that 58 percent of basic models of this equipment class already meet or exceed the thermal efficiency standards at TSL 1. At this level, DOE expects manufacturers of this equipment class to incur product conversion costs to redesign their equipment. DOE does not expect the modest increases in thermal efficiency requirements at this TSL to require capital investments. Overall, DOE estimates that manufacturers would incur $0.3 million in product conversion costs and no capital conversion costs to bring this equipment portfolio into compliance with a standard set to TSL 1. At TSL 1, product conversion costs are the key driver of results. These upfront investments result in a slightly lower INPV for the preservation of operating profit scenario and an almost unchanged INPV for the preservation of gross margin scenario.

At TSL 2, DOE estimates impacts on INPV ranges from -10.9 percent to 7.0 percent, or a change in INPV of -$4.4 million to $2.8 million. At this potential standard level, DOE estimates industry free cash flow to decrease by approximately 63.0 percent to $0.9 million compared to the no-new-standards-case value of $2.5 million in the year before compliance (2025).

DOE estimates that 39 percent of basic models of this equipment class already meet or exceed the thermal efficiency standards at TSL 2. DOE estimates that product and capital conversion costs would increase at this TSL. Manufacturers would meet the thermal efficiency levels by using condensing technology. DOE anticipates that manufacturers will begin to incur some product conversion costs associated with design changes to reach condensing levels. Additionally, DOE anticipates manufacturers achieving condensing levels with additional purchased parts (*i.e.*, condensing heat exchanger, burner tube, blower, gas valve). DOE's capital conversion costs reflect the incremental warehouse space required to store these additional purchased parts.

Overall, DOE estimates that industry would incur $1.9 million in product conversion costs and $2.0 million in capital conversion costs to bring their instantaneous circulating water heater and hot water supply boiler portfolio into compliance with a standard set to TSL 2.

As discussed in section V.A, TSL 3 and TSL 4 represent max-tech thermal efficiency levels for circulating water heater and hot water supply boiler equipment. Therefore, DOE modeled identical impacts to manufacturers of this equipment for both TSL 3 and TSL 4. At these levels, DOE estimates impacts on INPV to range from -24.3 percent to -2.7 percent, or a change in INPV of -$9.9 million to -$1.1 million. DOE estimates industry free cash flow in the year before compliance (2025) would decrease by approximately 161.3 percent to -$1.5 million compared to the no-new-standards case value of $2.5 million. DOE estimates that 29 percent of basic models of this equipment class already meet or exceed the max-tech thermal efficiency standards at these TSLs.

b. Direct Impacts on Employment

To quantitatively assess the potential impacts of amended energy conservation standards on direct employment in the CWH equipment 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. This analysis includes both production and non-production employees employed by CWH equipment manufacturers. DOE used statistical data from the U.S. Census Bureau 2021 Annual Survey of Manufacturers ("ASM")[178], the results of the engineering analysis, and interviews with manufacturers to determine the inputs necessary to calculate industry-wide labor expenditures and domestic employment levels. Labor expenditures related to manufacturing of the product are a function of 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 the GRIM are converted to domestic production worker employment levels by dividing production labor expenditures by the average fully burdened wage per production worker. DOE calculated the fully burdened wage by multiplying the industry production worker hourly blended wage (provided by the ASM) by the fully burdened wage ratio. The fully burdened wage ratio factors in paid leave, supplemental pay, insurance, retirement and savings, and legally required benefits. DOE determined the fully burdened ratio from the Bureau of Labor Statistic's employee compensation data.[179] The estimates of production workers in this section cover workers, including line-supervisors who are directly involved in fabricating and assembling a product within the manufacturing facility. Workers performing services that are closely

[178] U.S. Census Bureau, 2018-2021 Annual Survey of Manufacturers: Statistics for Industry Groups and Industries (2021) Available at *www.census.gov/programs-surveys/asm/data/tables.html* (Last accessed December 16, 2022).

[179] U.S. Bureau of Labor Statistics. *Employer Costs for Employee Compensation*. December 15, 2022. Available at *www.bls.gov/news.release/pdf/ecec.pdf* (Last accessed December 16, 2022)

associated with production operations, such as materials handling tasks using forklifts, are also included as production labor.

Non-production worker employment levels were determined by multiplying the industry ratio of production worker employment to non-production employment against the estimated production worker employment explained previously. Estimates of non-production workers in this section cover the line supervisors, sales, sales delivery, installation, office functions, legal, and technical employees.

The total direct employment impacts calculated in the GRIM are the sum of the changes in the number of domestic production and non-production workers resulting from the amended energy conservation standards for CWH equipment, as compared to the no-new-standards case. Typically, more efficient equipment is more complex and labor intensive to produce. Per-unit labor requirements and production time requirements trend higher with more stringent energy conservation standards.

DOE estimates that 92 percent of CWH equipment sold in the United States is currently manufactured domestically. In the absence of amended energy conservation standards, DOE estimates that there would be 168 domestic production workers in the CWH industry in 2026, the year of compliance. DOE notes that Congress authorized $250 million to Accelerate Electric Heat Pump Manufacturing in America utilizing the Defense Production Act. This program, funded by the Inflation Reduction Act (IRA), will increase use of electric heat pumps, which provide both heating and cooling for buildings and homes, will help lower energy costs for more American families and businesses, and create healthier indoor spaces through American-made clean energy technologies.

DOE's analysis forecasts that the industry will employ 296 production and non-production workers in the CWH industry in 2026 in the absence of amended energy conservation standards. Table V.29 presents the potential impacts of amended energy conservation standards on U.S. production workers of CWH equipment.

Table V.29 Domestic Direct Employment Impacts for CWH Manufacturers in 2026

	No-New-Standards Case	1	2	3	4
Direct Employment in 2026 (Production Workers + Non-Production Workers	296	300	291	300	307
Changes in Direct Employment	-	4	(5)	4	11

* Numbers in parentheses indicate negative numbers.
** This field presents impacts on domestic direct employment, which aggregates production and non-production workers. Based on ASM census data, DOE assumed the ratio of production to non-production employees stays consistent across all analyzed TSLs, which is 43 percent non-production workers.

In NOPR interviews conducted ahead of the 2016 NOPR notice, several manufacturers that produce high-efficiency CWH equipment stated that a standard that went to condensing levels could require them to hire more employees to increase their production capacity. Others stated that a condensing standard would require additional engineers to redesign CWH equipment and production processes. Due to different variations in manufacturing labor practices, actual direct employment could vary depending on manufacturers' preference for high capital or high labor practices in response to amended standards. DOE notes that the employment impacts discussed here are independent of the indirect employment impacts to the broader U.S. economy, which are documented in chapter 15 of the accompanying TSD.

c. Impacts on Manufacturing Capacity

As discussed in further detail in section IV.J.2.c of this document, DOE anticipates manufacturers would incur significant product conversion costs at TSL 4 (max-tech) for all gas-fired storage water heaters, gas-fired circulating water heaters, and hot water supply boilers. Because of the high conversion costs as this level, some manufacturers may not have the capacity to redesign the full range of equipment offerings in the 3-year conversion period. Instead, manufacturers would likely choose to offer a reduced selection of models to limit upfront investments.

Furthermore, none of the three largest manufacturers of commercial gas storage water heaters produces equipment that can meet the thermal efficiency standard at TSL 4. Currently, only two models from a single manufacturer can meet the thermal efficiency standard at TSL 4. This manufacturer is a small business and does not have the production capacity to meet the demand for the entire industry's shipments. Similarly, for residential-duty gas-fired storage water heaters, only one manufacturer offers models that can meet the UEF standard at TSL 4.

In written comments regarding TSL 3, two manufacturers with significant market share raised concerns about the ability to adapt products and update production capacity if standards for multiple equipment classes are set to max-tech. A.O. Smith raised concerns about the concurrent challenges of commercial gas-fired instantaneous, circulating product, and hot water supply boilers all having a new minimum standard of 96 percent thermal efficiency. A.O. Smith stated manufacturers will need to quickly shift resources and make significant capital investments to redesign and build these product types to "max-tech" technology within 3 years ahead of compliance with a final rule. (A.O. Smith, No.22 at p.3) Rheem stated increasing the energy conservation standards for commercial water heaters to the proposed near max-tech condensing levels, could significantly reduce equipment offerings from various manufacturers and lessen competition. Rheem attributed the reduction on offerings to a combination of limited compliance period of three years, the magnitude of the equipment and manufacturing changes that would be required, and the number of other rulemakings similarly affecting the water heating industry – specifically the anticipated changes in the energy conservation standards for consumer water heaters, consumer boilers, and pool heaters. (Rheem, No.24 at p.2)

d. Impacts on Subgroups of Manufacturers

Small manufacturers, niche equipment manufacturers, and manufacturers exhibiting a cost structure substantially different from the industry average could be affected disproportionately. Using average cost assumptions developed for an industry cash-flow estimate is inadequate to assess differential impacts among manufacturer subgroups.

For the CWH equipment industry, DOE identified and evaluated the impact of amended energy conservation standards on one subgroup—small manufacturers. The SBA defines a "small business" as having 1,000 employees or fewer for NAICS code 333310, "Other Commercial and Service Industry Machinery Manufacturing." Based on this definition, DOE identified three small, domestic manufacturers of the covered equipment that would be subject to amended standards.

For a discussion of the impacts on the small manufacturer subgroup, see the regulatory flexibility analysis in section VI.B of this document and chapter 12 of the final rule TSD.

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. Assessing the impact of a single regulation may overlook this cumulative regulatory burden. In addition to energy conservation standards, other regulations can significantly affect manufacturers' financial operations. 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.

Rheem noted that the company faces cumulative regulatory burden from space conditioning and refrigeration rulemakings. (Rheem, No. 24 at p. 7) DOE identified

DOE rulemakings affecting Rheem and other CWH manufacturer that are Federal, are product-specific, and that will take effect three years before or after the estimated 2026 compliance date (see Table V.30).

Table V.30 Compliance Dates and Expected Conversion Expenses of Federal Energy Conservation Standards Affecting Commercial Water Heater Manufacturers

Federal Energy Conservation Standard	Number of Manufacturers*	Number of Manufacturers Affected from Today's Rule**	Approx. Standards Year	Industry Conversion Costs *Millions $*	Industry Conversion Costs / Product Revenue†
Commercial Warm Air Furnaces 81 FR 2420 (January 15, 2016)	14	2	2023	7.5 - 22.2 (2014$)	1.7% - 5.1%††
Residential Central Air Conditioners and Heat Pumps 82 FR 1786 (January 6, 2017)	30	3	2023	342.6 (2015$)	0.5%
Room Air Conditioners‡ 87 FR 20608 (April 7, 2022)	30	1	2023	22.8 (2020$)	0.5%
Consumer Pool Heaters‡ 87 FR 22640 (April 15, 2022)	21	3	2028	33.8 (2020$)	1.9%
Consumer Furnaces‡ 87 FR 40590 (July 7, 2022)	15	1	2029	150.6 (2020$)	1.4%

* This column presents the total number of manufacturers identified in the energy conservation standard rule contributing to cumulative regulatory burden.
** This column presents the number of manufacturers producing CWH equipment that are also listed as manufacturers in the listed energy conservation standard 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 time frame over which conversion costs are made and lasts from the announcement year of the final rule to the standards year of the final rule. The conversion period typically ranges from 3 to 5 years, depending on the energy conservation standard.
††Low and high conversion cost scenarios were analyzed as part of this direct final rule. The range of estimated conversion expenses presented here reflects those two scenarios.
‡ These rulemakings are in the proposed rule stage and all values are subject to change until finalized.

In written comments, AHRI and Bradford White listed several rulemakings that do not appear in Table V.31. (AHRI, No. 13 at pp. 5-6; Bradford White, NO.23 at p.7) DOE published a March 2022 ECS preliminary analysis for consumer water heaters, a May 2022 ECS preliminary analysis for consumer boilers, and an August 2022 NODA for commercial and industrial pumps. (87 FR 11327; 87 FR 26304; 87 FR 49537) These rulemakings do not have final rules, nor do they have proposed standard levels or proposed compliance dates. Any estimation of cost or timing at this time would be speculative. DOE does not list test procedures in Table V.32. When applicable, test procedure costs are incorporated into the associated energy conservation standard rulemakings.

AHRI also identified the proposed rule for small electric motors as potential cumulative regulatory burden. DOE notes that those energy conservation standards for small electric motors do not apply to small electric motors that are components of other DOE-regulated products. (42 U.S.C. 6317 (b)(3)) Additionally, the analysis for small electric motors takes into consideration important attributes of motors that affect selection in end use applications.[180] DOE has not included the small electric motor rulemaking in its analysis of cumulative regulatory burden. AHRI also noted that the DOE rulemakings for Federal Commercial and Multi-family High-rise Residential Buildings and Federal Low-rise Residential Buildings Design and Construction may "indirectly affect" CWH manufacturers. The rulemakings do not directly regulate

[180] DOE notes that on February 6, 2023, DOE issued a notice of proposed determination in which it initially determined that amended energy conservation standards for small electric motors would not be cost-effective, and therefore proposed not to amend its energy conservation standards for small electric motors. 88 FR 7629.

manufacturers of commercial water heaters and are not directly considered in the CRB analysis. However, DOE did account for these rules in its shipments analysis as described in section IV.G.4 of this document.

A.O. Smith noted that manufacturers will potentially make additional investments in response to the ENERGY STAR® program's recent publication of its final residential water heater version 5.0 specification, which sets a ≥ 0.86 UEF value for gas-fired residential-duty commercial water heaters effective April 28, 2023. (A.O. Smith, No. 22 at p.4) DOE does not consider voluntary programs, such as ENERGY STAR®, in its analysis of cumulative regulatory burden.

WM Technologies and Patterson-Kelley both noted that industry has limited resources to monitor and prepare for possible changes in standards, and that the current regulatory push by the DOE and other Federal agencies is placing tremendous stress upon all industries, especially the heating industry. (WM Technologies, No. 25 at pp. 8–9; Patterson-Kelley, No. 26 at p. 6) DOE acknowledges the commenters concerns and has considered the impacts of this final rule on manufacturers as described throughout this section. Additionally, as noted in section II.A of this document, pursuant to EPCA, DOE is obligated by law to consider amending the energy efficiency standards for certain types of commercial and industrial equipment, including CWH equipment, whenever ASHRAE amends the standard levels or design requirements prescribed in ASHRAE/IES Standard 90.1, and at a minimum, every 6 years. (42 U.S.C. 6313(a)(6)(A)-(C)) DOE also notes that between March 2016 and January 2021, DOE missed legal deadlines for a range of rulemakings. In October 2020, a coalition of non-governmental organizations filed suit under EPCA alleging that DOE has failed to meet rulemaking deadlines for 25 different consumer products and commercial equipment. In September 2022, DOE settled the lawsuit over the missed rulemaking deadlines to review and update energy efficiency standards. As part of the court-approved settlement, DOE has agreed to a schedule to review these regulations and, as appropriate, update them to improve efficiency requirements. DOE continues to evaluate the impact of rulemakings on manufacturers and welcomes input of the direct cost of monitoring possible changes in standards for incorporation into analyses.

3. National Impact Analysis

This section presents DOE's estimates of the NES and the NPV of consumer benefits that would result from each of the TSLs considered as potential amended standards.

a. Significance of Energy Savings

To estimate the energy savings attributable to potential amended standards for CWH equipment, 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 (2026–2055). Table V.33 presents DOE's projections of the NES for each TSL considered for CWH equipment. The savings were calculated using the approach described in section IV.H of this document.

Table V.33 Cumulative National Energy Savings for CWH equipment; 30 Years of Shipments (2026–2055)

	Trial Standard Level			
	1	2	3	4
	quads			
Primary Energy				
Commercial gas-fired storage and storage-type instantaneous	0.03	0.16	0.25	0.43
Residential-duty gas-fired storage	0.04	0.08	0.12	0.14
Instantaneous gas-fired tankless	0.00	0.01	0.02	0.02
Instantaneous circulating water heaters and hot water supply boilers	0.02	0.19	0.23	0.23
Total Primary Energy	**0.10**	**0.44**	**0.62**	**0.82**
FFC Energy				
Commercial gas-fired storage and storage-type instantaneous	0.04	0.18	0.28	0.48
Residential-duty gas-fired storage	0.05	0.09	0.13	0.16
Instantaneous gas-fired tankless	0.00	0.02	0.02	0.02
Instantaneous circulating water heaters and hot water supply boilers	0.03	0.21	0.26	0.26
Total FFC Energy	**0.12**	**0.49**	**0.70**	**0.92**

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

[181] United States Office of Management and Budget. *Circular A-4: Regulatory Analysis*. September 17, 2003. Available at *www.whitehouse.gov/omb/information-for-agencies/circulars/* (last accessed December 13, 2022).
[182] Section 325(m) of 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,

synchronized with the product lifetime, product manufacturing cycles, or other factors specific to commercial 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.34. The impacts are counted over the lifetime of commercial water heaters purchased in 2026–2034.

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except that in no case may any new standards be required within 6 years of the compliance date of the previous standards. 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.34 Cumulative National Energy Savings for CWH Equipment; 9 Years of Shipments (2026–2034)

	Trial Standard Level			
	1	**2**	**3**	**4**
	quads			
Primary Energy				
Commercial gas-fired storage and storage-type instantaneous	0.01	0.06	0.09	0.14
Residential-duty gas-fired storage	0.01	0.03	0.04	0.05
Instantaneous gas-fired tankless	0.00	0.00	0.00	0.00
Instantaneous circulating water heaters and hot water supply boilers	0.01	0.05	0.06	0.06
Total Primary Energy	**0.03**	**0.13**	**0.19**	**0.25**
FFC Energy				
Commercial gas-fired storage and storage-type instantaneous	0.01	0.06	0.10	0.16
Residential-duty gas-fired storage	0.01	0.03	0.04	0.05
Instantaneous gas-fired tankless	0.00	0.00	0.00	0.00
Instantaneous circulating water heaters and hot water supply boilers	0.01	0.05	0.06	0.06
Total FFC Energy	**0.04**	**0.15**	**0.21**	**0.28**

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 CWH equipment. 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.35 shows the consumer NPV results with impacts counted over the lifetime of equipment purchased in 2026–2055.

[183] United States Office of Management and Budget. *Circular A-4: Regulatory Analysis*. September 17, 2003. Available at *www.whitehouse.gov/omb/information-for-agencies/circulars/* (last accessed December 13, 2022).

Table V.35 Cumulative Net Present Value of Consumer Benefits for CWH Equipment; 30 Years of Shipments (2026–2055)

Discount Rate	Trial Standard Level*			
	1	2	3	4
	billion 2022$			
3 percent				
Commercial gas-fired storage and storage-type instantaneous	0.15	0.41	0.81	1.51
Residential-duty gas-fired storage	0.16	0.17	0.27	0.38
Instantaneous gas-fired tankless	0.02	0.03	0.04	0.04
Instantaneous circulating water heaters and hot water supply boilers	0.08	0.18	0.30	0.30
Total NPV at 3 percent	**0.41**	**0.79**	**1.43**	**2.25**
7 percent				
Commercial gas-fired storage and storage-type instantaneous	0.07	0.13	0.32	0.65
Residential-duty gas-fired storage	0.07	0.04	0.08	0.13
Instantaneous gas-fired tankless	0.01	0.01	0.01	0.01
Instantaneous circulating water heaters and hot water supply boilers	0.03	(0.02)	0.02	0.02
Total NPV at 7 percent	**0.18**	**0.15**	**0.43**	**0.81**

* A value in parentheses is a negative number.

The NPV results based on the aforementioned 9-year analytical period are presented in Table V.36. The impacts are counted over the lifetime of equipment purchased in 2026–2034. 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.36 Cumulative Net Present Value of Consumer Benefits CWH Equipment; 9 Years of Shipments (2026–2034)

Discount Rate	Trial Standard Level *			
	1	2	3	4
	billion 2022$			
3 percent				
Commercial gas-fired storage and storage-type instantaneous	0.07	0.04	0.20	0.47
Residential-duty gas-fired storage	0.06	0.02	0.06	0.10
Instantaneous gas-fired tankless	0.01	0.00	0.01	0.01
Instantaneous circulating water heaters and hot water supply boilers	0.03	0.04	0.08	0.08
Total NPV at 3 percent	**0.16**	**0.10**	**0.35**	**0.66**
7 percent				
Commercial gas-fired storage and storage-type instantaneous	0.04	(0.01)	0.09	0.26
Residential-duty gas-fired storage	0.04	(0.01)	0.01	0.04
Instantaneous gas-fired tankless	0.00	0.00	0.00	0.00
Instantaneous circulating water heaters and hot water supply boilers	0.01	(0.02)	0.00	0.00
Total NPV at 7 percent	**0.10**	**(0.04)**	**0.11**	**0.30**

* A value in parentheses is a negative number.

c. Indirect Impacts on Employment

DOE estimates that amended energy conservation standards for CWH equipment will reduce energy expenditures for consumers of this equipment, 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 (2026–2030), in which 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.d of this document, DOE has concluded that the standards adopted in this final rule will not lessen the utility or performance of the CWH equipment 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 final rule and the TSD for review. In its assessment letter responding to DOE, DOJ concluded that the proposed energy conservation standards for CWH equipment 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. 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 CWH equipment is expected to yield environmental benefits in the form of reduced emissions of certain air pollutants and greenhouse gases. Table V.37 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.38 presents cumulative FFC emissions by equipment class.

Table V.37 Cumulative Emissions Reduction for CWH Equipment Shipped in 2026–2055

	Trial Standard Level			
	1	**2**	**3**	**4**
Power Sector Emissions				
CO_2 (*million metric tons*)	5.7	23.9	33.5	44.0
SO_2 (*thousand tons*)	(0.00)	0.02	0.08	0.15
NO_X (*thousand tons*)	5.07	21.16	29.54	38.71
Hg (*tons*)	(0.000)	(0.001)	(0.001)	(0.001)
CH_4 (*thousand tons*)	0.11	0.48	0.68	0.90
N_2O (*thousand tons*)	0.011	0.047	0.067	0.089
Upstream Emissions				
CO_2 (*million metric tons*)	0.8	3.3	4.7	6.1
SO_2 (*thousand tons*)	0.00	0.01	0.02	0.03
NO_X (*thousand tons*)	13	53	74	97
Hg (*tons*)	(0.000)	(0.000)	(0.000)	(0.000)
CH_4 (*thousand tons*)	82	342	478	627
N_2O (*thousand tons*)	0.001	0.006	0.008	0.011
Total FFC Emissions				
CO_2 (*million metric tons*)	6.5	27.3	38.2	50.1
SO_2 (*thousand tons*)	0.00	0.03	0.10	0.17
NO_X (*thousand tons*)	18	74	103	135
Hg (*tons*)	(0.000)	(0.001)	(0.001)	(0.001)
CH_4 (*thousand tons*)	82	343	479	628
N_2O (*thousand tons*)	0.012	0.053	0.075	0.100

Negative values refer to an increase in emissions.

Table V.38 Cumulative FFC Emissions Reduction for CWH Equipment Shipped in 2026–2055, by Equipment Class

	Trial Standard Level			
	1	**2**	**3**	**4**
Total FFC Emissions, Commercial Gas Storage and Storage-Type Instantaneous				
CO_2 (*million metric tons*)	2.0	9.8	15.5	26.0
SO_2 (*thousand tons*)	0.01	(0.00)	0.03	0.10
NO_X (*thousand tons*)	5.5	26.7	42.0	70.3
Hg (*tons*)	0.0000	(0.0004)	(0.0003)	(0.0003)
CH_4 (*thousand tons*)	25.5	123.8	194.8	326.0
N_2O (*thousand tons*)	0.004	0.019	0.030	0.052
Total FFC Emissions, Residential-Duty Gas-Fired Storage				
CO_2 (*million metric tons*)	2.5	5.1	7.4	8.8
SO_2 (*thousand tons*)	0.00	(0.01)	0.00	0.01
NO_X (*thousand tons*)	6.8	13.9	20.1	23.9
Hg (*tons*)	(0.0001)	(0.0003)	(0.0003)	(0.0003)
CH_4 (*thousand tons*)	31.6	64.5	93.2	110.8
N_2O (*thousand tons*)	0.00	0.01	0.01	0.02
Total FFC Emissions, Instantaneous Gas-Fired Tankless				
CO_2 (*million metric tons*)	0.3	0.9	1.1	1.1
SO_2 (*thousand tons*)	0.00	0.01	0.01	0.01
NO_X (*thousand tons*)	0.71	2.30	3.05	3.05
Hg (*tons*)	0.0000	0.0000	0.0000	0.0000
CH_4 (*thousand tons*)	3.29	10.63	14.11	14.11
N_2O (*thousand tons*)	0.00	0.00	0.00	0.00
Total FFC Emissions, Instantaneous Circulating Water Heaters and Hot Water Supply Boilers				
CO_2 (*million metric tons*)	1.7	11.5	14.1	14.1
SO_2 (*thousand tons*)	(0.02)	0.04	0.06	0.06
NO_X (*thousand tons*)	4.7	31.2	38.3	38.3
Hg (*tons*)	(0.0002)	(0.0001)	(0.0001)	(0.0001)
CH_4 (*thousand tons*)	21.7	143.9	176.7	176.7
N_2O (*thousand tons*)	0.00	0.02	0.03	0.03

Negative values refer to an increase in emissions.

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 CWH equipment. Section IV.L of this document discusses the estimated SC-CO_2 values that DOE used. Table V.39 presents the value of CO_2 emissions reduction at each TSL.

Table V.39 Present Value of CO_2 Emissions Reduction for CWH Equipment Shipped in 2026–2055

TSL	SC-CO_2 Case			
	Discount Rate and Statistics			
	5%	3%	2.5%	3%
	Average	Average	Average	95th percentile
	million 2022$			
1	67	285	445	867
2	272	1,163	1,817	3,531
3	386	1,642	2,563	4,986
4	517	2,189	3,411	6,650

As discussed in section IV.L, DOE estimated the climate benefits likely to result from the reduced emissions of CH_4 and N_2O that DOE estimated for each of the considered TSLs for CWH equipment. Table V.40 presents the value of the CH_4 emissions reduction at each TSL, and Table V.41 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.40 Present Value of Methane Emissions Reduction for CWH Equipment Shipped in 2026–2055

TSL	SC-CH_4 Case			
	Discount Rate and Statistics			
	5%	3%	2.5%	3%
	Average	Average	Average	95th percentile
	million 2022$			
1	39	114	159	303
2	159	469	653	1,241
3	224	659	917	1,745
4	300	874	1,214	2,315

Table V.41 Present Value of Nitrous Oxide Emissions Reduction for CWH Equipment Shipped in 2026–2055

TSL	SC-N_2O Case			
	Discount Rate and Statistics			
	5%	3%	2.5%	3%
	Average	Average	Average	95th percentile
	million 2022$			
1	0.05	0.19	0.30	0.51
2	0.20	0.79	1.22	2.10
3	0.28	1.13	1.76	3.02
4	0.39	1.53	2.36	4.07

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 would be 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 CWH equipment. The dollar-per-ton values that DOE used are discussed in section IV.L of this document. Table V.42 presents the present value for NO_X emissions reduction for each TSL calculated using 7-percent and 3-percent discount rates, and Table V.43 presents similar results for SO_2 emissions reductions. The results in these tables reflect application of the low dollar-per-ton values, which DOE used to be conservative. Results that reflect high dollar-per-ton values are presented in chapter 14 of the final rule TSD.

Table V.42 Present Value of NO_X Emissions Reduction for CWH Equipment Shipped in 2026-2055

TSL	3% Discount Rate	7% Discount Rate
	million 2022$	
1	573	240
2	2,330	949
3	3,290	1,356
4	4,390	1,840

Table V.43 Present Value of SO_2 Emissions Reduction for CWH Equipment Shipped in 2026-2055

TSL	3% Discount Rate	7% Discount Rate
	million 2022$	
1	(0.40)	(0.11)
2	(1.19)	(0.82)
3	1.87	0.51
4	5.38	2.10

DOE has not considered the monetary benefits of the reduction of Hg for this final rule. 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 Hg, direct particulate matter ("PM"), and other co-pollutants may be significant.

The benefits of reduced CO_2, CH_4, and N_2O emissions are collectively referred to as climate benefits. The benefits of reduced SO_2 and NO_X emissions are collectively referred to as health benefits. For the time-series of estimated monetary values of reduced emissions, see chapter 14 of the final rule TSD.

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. 6313(a)(6)(B)(ii)(VII)) No other factors were considered in this analysis.

8. Summary of Economic Impacts

Table V.44 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 commercial water heaters, and they are measured for the lifetime of products shipped in 2026–2055. The climate benefits associated with reduced GHG emissions resulting from the adopted standards are global benefits, which are also calculated based on the lifetime of commercial water heaters shipped in 2026–2055. The climate benefits associated with four SC-GHG estimates are shown. DOE does not have a single central SC-GHG point estimate and it emphasizes the importance and value of considering the benefits calculated using all four SC-GHG estimates.

Table V.44 NPV of Consumer Benefits Combined with Climate and Health Benefits from Emissions Reductions

Category	TSL 1	TSL 2	TSL 3	TSL 4
3% discount rate for NPV of Consumer and Health Benefits (billion 2022$)				
5% d.r., Average SC-GHG case	1.09	3.55	5.33	7.46
3% d.r., Average SC-GHG case	1.38	4.75	7.02	9.71
2.5% d.r., Average SC-GHG case	1.59	5.59	8.20	11.27
3% d.r., 95th percentile SC-GHG case	2.15	7.89	11.46	15.61
7% discount rate for NPV of Consumer and Health Benefits (billion 2022$)				
5% d.r., Average SC-GHG case	0.53	1.54	2.40	3.47
3% d.r., Average SC-GHG case	0.82	2.74	4.09	5.72
2.5% d.r., Average SC-GHG case	1.03	3.57	5.27	7.28
3% d.r., 95th percentile SC-GHG case	1.59	5.88	8.52	11.62

The national operating cost savings are domestic U.S. monetary savings that occur as a result of purchasing CWH equipment, and are measured for the lifetime of products shipped in 2026–2055. The benefits associated with reduced GHG emissions achieved as a result of the adopted standards are also calculated based on the lifetime of CWH equipment shipped in 2026–2055.

C. Conclusion

As noted previously, EPCA specifies that, for any commercial and industrial equipment addressed under 42 U.S.C. 6313(a)(6)(A)(i), DOE may prescribe an energy conservation standard more stringent than the level for such equipment in ASHRAE Standard 90.1, as amended, only if “clear and convincing evidence” shows that a more-stringent standard would result in significant additional conservation of energy and is technologically feasible and economically justified. (42 U.S.C. 6313(a)(6)(A)(ii)(II)) 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. 6313(a)(6)(B)(ii)(I)-(VII) and 42 U.S.C. 6313(a)(6)(C)(i))

For this final rule, DOE considered the impacts of amended standards for CWH equipment at each TSL, beginning with the max-tech 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 upfront 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.

1. Benefits and Burdens of TSLs Considered for CWH Equipment Standards

Table V.45 and Table V.46 summarize the quantitative impacts estimated for each TSL for CWH equipment. The national impacts are measured over the lifetime of each class of CWH equipment purchased in the 30-year period that begins in the anticipated year of compliance with amended standards (2026–2055). The energy savings, emissions reductions, and value of emissions reductions refer to full-fuel-cycle results. DOE is presenting monetized benefits in accordance with the applicable Executive Orders and DOE would reach the same conclusion presented in this notice in the absence of the SC-GHG, including the Interim Estimates presented by the Interagency Working Group. The efficiency levels contained in each TSL are described in section V.A of this document.

Table V.45 Summary of Analytical Results for CWH Equipment TSLs: National Impacts

Category	TSL 1	TSL 2	TSL 3	TSL 4
Cumulative FFC National Energy Savings (*quads*)				
Commercial gas-fired storage and storage-type instantaneous	0.04	0.18	0.28	0.48
Residential-duty gas-fired storage	0.05	0.09	0.13	0.16
Instantaneous gas-fired tankless	0.00	0.02	0.02	0.02
Instantaneous circulating water heaters and hot water supply boilers	0.03	0.21	0.26	0.26

Category	TSL 1	TSL 2	TSL 3	TSL 4
Total Quads	**0.12**	**0.49**	**0.70**	**0.92**
NPV of Consumer Costs and Benefits (*billion 2022$*)				
NPV at 3% discount rate				
Commercial gas-fired storage and storage-type instantaneous	0.15	0.41	0.81	1.51
Residential-duty gas-fired storage	0.16	0.17	0.27	0.38
Instantaneous gas-fired tankless	0.02	0.03	0.04	0.04
Instantaneous circulating water heaters and hot water supply boilers	0.08	0.18	0.30	0.30
Total NPV at 3% (billion 2022$)	**0.41**	**0.79**	**1.43**	**2.25**
NPV at 7% discount rate				
Commercial gas-fired storage and storage-type instantaneous	0.07	0.13	0.32	0.65
Residential-duty gas-fired storage	0.07	0.04	0.08	0.13
Instantaneous gas-fired tankless	0.01	0.01	0.01	0.01
Instantaneous circulating water heaters and hot water supply boilers	0.03	(0.02)	0.02	0.02
Total NPV at 7% (billion 2022$)	**0.18**	**0.15**	**0.43**	**0.81**
Cumulative FFC Emissions Reduction (Total FFC Emissions)				
CO_2 (*million metric tons*)	7	27	38	50
SO_2 (*thousand tons*)	0.00	0.03	0.10	0.17
NO_X (*thousand tons*)	18	74	103	135
Hg (*tons*)	(0.000)	(0.001)	(0.001)	(0.001)
CH_4 (*thousand tons*)	82	343	479	628
N_2O (*thousand tons*)	0.01	0.05	0.08	0.10
Present Value of Benefits and Costs (*3% discount rate, billion 2022$*)				
Consumer Operating Cost Savings	0.51	1.87	2.76	3.83
Climate Benefits*	0.40	1.63	2.30	3.06
Health Benefits**	0.57	2.33	3.29	4.40
Total Benefits†	1.49	5.83	8.35	11.29
Consumer Incremental Product Costs‡	0.10	1.08	1.33	1.58
Consumer Net Benefits	0.41	0.79	1.43	2.25
Total Net Benefits	1.38	4.75	7.02	9.71
Present Value of Benefits and Costs (*7% discount rate, billion 2022$*)				
Consumer Operating Cost Savings	0.24	0.86	1.28	1.81
Climate Benefits*	0.40	1.63	2.30	3.06
Health Benefits**	0.24	0.95	1.36	1.84
Total Benefits†	0.88	3.44	4.94	6.71
Consumer Incremental Product Costs‡	0.06	0.70	0.85	1.00
Consumer Net Benefits	0.18	0.15	0.43	0.81
Total Net Benefits	0.82	2.74	4.09	5.72

Note: This table presents the costs and benefits associated with commercial water heaters shipped in 2026−2055. These results include benefits to consumers which accrue after 2055 from the products shipped in 2026−2055.

* 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), as shown in Table V.39 through Table V.41. Together these represent the global social cost of greenhouse gases (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 importance and 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 $PM_{2.5}$ and (for NO_X) ozone precursor health benefits, but will continue to assess the ability to monetize other effects

Category	TSL 1	TSL 2	TSL 3	TSL 4

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.46 Summary of Analytical Results for CWH Equipment TSLs: Manufacturer and Consumer Impacts

Category	TSL 1*	TSL 2*	TSL 3*	TSL 4*
Manufacturer Impacts: INPV (*million 2022$*)				
Commercial gas-fired storage and storage-type instantaneous (No-new-standards case INPV = 154.2)	153.3 - 154.0	139.1 - 142.7	130.4 - 136.5	62.0 - 73.1
Residential-duty gas-fired storage (No-new-standards case INPV = 9.0)	8.4 - 9.6	7.6 - 9.6	6.5 - 011.2	2.3 - 7.4
Instantaneous gas-fired tankless (No-new-standards case INPV = 8.9)	8.3 - 8.4	7.2 - 7.5	7.2 - 7.6	7.2 - 7.6
Instantaneous circulating water heaters and hot water supply boilers (No-new-standards case INPV = 40.8)	40.6 - 40.7	36.3 - 43.6	30.9 - 39.7	30.9 - 39.7
Total INPV ($) (No-new-standards case INPV = 212.8)	210.7 - 212.7	190.3 - 203.5	175.1 - 195.1	102.7 - 128.1
Manufacturer Impacts: Industry NPV (% Change)				
Commercial gas-fired storage and storage-type instantaneous	(0.6) - (0.1)	(9.7) - (7.4)	(15.4) - (11.4)	(59.8) - (52.6)
Residential-duty gas-fired storage	(5.8) - 6.8	(15.3) - 7.4	(27.3) - 25.0	(74.7) - (16.9)
Instantaneous gas-fired tankless	(6.0) - (5.6)	(18.6) - (15.6)	(19.0) - (14.2)	(19.0) - (14.2)
Instantaneous circulating water heaters and hot water supply boilers	(0.5) - (0.1)	(10.9) - 7.0	(24.3) - (2.7)	(24.3) - (2.7)
Total INPV (*% change*)	(1.0) - (0.0)	(10.6) - (4.4)	(17.7) - (8.3)	(51.8) - (39.8)
Consumer Average LCC Savings (*2022$*)				
Commercial Gas-Fired Storage and Storage-type Instantaneous Water Heaters	267	(85)	367	528
Residential-Duty Gas-Fired Storage	509	(80)	119	370
Gas-Fired Instantaneous Water Heaters and Hot Water Supply Boilers	756	695	898	898
– Instantaneous, Gas-Fired Tankless	295	105	120	120
– Instantaneous Water Heaters and Hot Water Supply Boilers	1,153	1,204	1,570	1,570
Shipment-Weighted Average*	384	49	423	569
Consumer Simple PBP (*years*)				
Commercial Gas-Fired Storage and Storage-type Instantaneous Water Heaters	2	8	6	5

Category	TSL 1*	TSL 2*	TSL 3*	TSL 4*
Residential-Duty Gas-Fired Storage	3	8	7	6
Gas-Fired Instantaneous Water Heaters and Hot Water Supply Boilers	1	10	9	9
– Instantaneous, Gas-Fired Tankless	1	9	9	9
– Instantaneous Water Heaters and Hot Water Supply Boilers	1	10	9	9
Shipment-Weighted Average*	2	8	7	6
Percent of Consumers that Experience a Net Cost				
Commercial Gas-Fired Storage and Storage-type Instantaneous Water Heaters	3%	19%	17%	23%
Residential-Duty Gas-Fired Storage	6%	43%	42%	37%
Gas-Fired Instantaneous Water Heaters and Hot Water Supply Boilers	1%	14%	17%	17%
– Instantaneous, Gas-Fired Tankless	0%	10%	15%	15%
– Instantaneous Water Heaters and Hot Water Supply Boilers	2%	17%	18%	18%
Shipment-Weighted Average*	3%	21%	21%	24%

Parentheses indicate negative (-) values.
* Weighted by shares of each equipment class in total projected shipments in 2026.

DOE first considered TSL 4, which represents the max-tech efficiency levels. At this TSL, the Secretary has determined that the benefits are outweighed by the burdens, as discussed in detail in the following paragraphs.

TSL 4 would save an estimated 0.92 quads of energy, an amount DOE considers significant. Commercial gas-fired storage water heaters and storage-type instantaneous water heaters save an estimated 0.48 quads while residential-duty gas-fired storage equipment saves 0.16 quads of energy. Instantaneous gas-fired tankless water heaters are estimated to save 0.02 quads of energy, while instantaneous circulating water heaters and hot water supply boilers save an estimated 0.26 quads.

Under TSL 4, the NPV of consumer benefit would be $0.81 billion using a discount rate of 7 percent, and $2.25 billion using a discount rate of 3 percent. Much of the consumer benefit is provided by the commercial gas-fired storage water heaters and storage-type instantaneous water heaters, totaling an estimated \$0.65 billion using a 7-percent discount rate, and \$1.51 billion using a 3-percent discount rate. The consumer benefit for residential-duty gas-fired storage water heaters is estimated to be \$0.13 billion at a 7-percent discount rate and \$0.38 billion at a 3-percent discount rate. The consumer benefit for instantaneous gas-fired tankless water heaters is estimated to be \$0.01 billion at a 7-percent discount rate and \$0.04 at a 3-percent discount rate, and the consumer benefit for instantaneous circulating water heaters and hot water supply boilers is estimated to be \$0.02 billion at a 7-percent discount rate and \$0.30 billion at a 3-percent discount rate.

The cumulative emissions reductions at TSL 4 are 50 million metric tons of CO_2, 0.17 thousand tons of SO_2, 135 thousand tons of NO_X, -0.001 ton of Hg, 628 thousand tons of CH_4, and 0.10 thousand tons of N_2O. 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 \$3.06 billion. The estimated monetary value of the health benefits from reduced NO_X and SO_2 emissions at TSL 4 is \$1.84 billion using a 7-percent discount rate and \$4.40 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 \$5.72 billion. Using a 3-percent discount rate for all benefits and costs, the estimated total NPV at TSL 4 is \$9.71 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 4, the average LCC impact is a savings of $528 for commercial gas-fired storage and storage-type instantaneous water heaters, $370 for residential-duty gas-fired storage water heaters, $120 for instantaneous gas-fired instantaneous water heaters, and $1,570 for instantaneous circulating water heaters and hot water supply boilers. The simple PBP is 5 years for commercial gas-fired storage water heaters, 6 years for residential-duty gas-fired storage water heaters, 9 years for instantaneous gas-fired tankless water heaters, and 9 years for instantaneous circulating water heaters and hot water supply boilers. The fraction of consumers experiencing a net LCC cost is 23 percent for commercial gas-fired storage water heaters and storage-type instantaneous water heaters, 37 percent for residential-duty gas-fired storage water heaters, 15 percent for instantaneous gas-fired tankless water heaters, and 18 percent for instantaneous circulating water heaters and hot water supply boilers.

At TSL 4, the projected change in manufacturer INPV ranges from a decrease of $110.1 million to a decrease of $84.6 million, which corresponds to decreases of 51.8 percent and 39.8 percent, respectively. Conversion costs total $132.2 million.

Commercial gas-fired storage water heaters and storage-type instantaneous equipment currently account for approximately 68 percent of current unit shipments in the CWH industry. The projected change in manufacturer INPV for commercial gas-fired storage water heaters and storage-type instantaneous equipment ranges from a decrease of $92.1 million to a decrease of $81.0 million, which corresponds to decreases of 59.8 percent and 52.6 percent, respectively. The potentially large negative impacts on INPV are largely driven by industry conversion costs. In particular, there are substantial increases in product conversion costs at TSL 4 for commercial gas-fired storage water heaters and storage-type instantaneous equipment manufacturers. There are several factors that lead to high product conversion costs for this equipment.

Currently, only two models of this equipment type from a single manufacturer can meet a 99 percent thermal efficiency standard, which represents less than 1 percent of the commercial gas-fired storage water heaters and storage-type instantaneous equipment models currently offered on the market. The two models both have an input capacity of 300,000 Btu/h and share a similar design. The manufacturer of these models is a small business with less than 1 percent market share in the commercial gas storage water heater market. The company's ability to ramp-up production capacity at 99 percent thermal efficiency to serve a significantly larger portion of the market is unclear.

Nearly all existing models would need to be redesigned to meet a 99 percent thermal efficiency standard. Traditionally, manufacturers design their equipment platforms to support a range of models with varying input capacities and storage volumes, and the efficiency typically will vary slightly between models within a given platform. However, at TSL 4, manufacturers would not be able to maintain a platform approach to designing commercial gas-fired storage water heaters because the 99 percent thermal efficiency level represents the maximum achievable efficiency and there would be no allowance for slight variations in efficiency between individual models. At TSL 4, manufacturers would be required to individually redesign each model to optimize performance for one specific input capacity and storage volume combination. As a result, the industry's level of engineering effort and investment would grow significantly. In manufacturer interviews, some manufacturers raised concerns that they would not have sufficient engineering capacity to complete necessary redesigns within the 3-year conversion period. If manufacturers require more than 3 years to redesign all models, they would likely prioritize redesigns based on sales volume. There is risk that some models become unavailable, either temporarily or permanently.

Product conversion costs for commercial gas-fired storage water heaters and storage-type instantaneous equipment are expected to reach $84.1 million over the 3-year conversion period. These investment levels are six times greater than typical R&D spending on this equipment class over a three-year period. Compliance with DOE standards could limit other engineering and innovation efforts, such as developing heat pump water heaters for the commercial market, during the conversion period beyond compliance with amended energy conservation standards.

Residential-duty gas-fired storage water heaters account for approximately 14 percent of current unit shipments in the CWH industry. At TSL 4, the projected change in INPV for residential-duty gas-fired storage water heaters ranges from a decrease of $6.7 million to a decrease of $1.5 million, which corresponds to decreases of 74.7 percent and 16.9 percent, respectively. Conversion costs total $7.3 million.

The drivers of negative impacts on INPV for residential-duty gas-fired storage water heaters are largely identical to those identified for the commercial gas-fired storage water heaters. At TSL 4, there is only one manufacturer with a compliant model at this standard level. This represents less than 2 percent of models currently offered in the market. Product conversion costs are expected to reach $4.8 million over the conversion period as manufacturers have to optimize designs for each specific input capacity and storage volume combination.

Instantaneous gas-fired tankless water heaters account for approximately 9 percent of current unit shipments in the CWH industry. At TSL 4, the projected change in manufacturer INPV for instantaneous gas-fired tankless water heaters ranges from a decrease of $1.7 million to a decrease of $1.3 million, which corresponds to decreases of 19.0 percent and 14.2 percent, respectively. Conversion costs total $2.1 million.

At TSL 4, approximately 64 precent of currently offered instantaneous gas-fired tankless water heaters models would meet TSL 4 today. While most manufacturers have some compliant models, manufacturers would likely develop cost-optimized models to compete in a market where energy efficiency provides less product differentiation. Product conversion cost are expected to reach $1.5 million.

Instantaneous circulating water heaters and hot water supply boilers account for approximately 10 percent of current unit shipments in the CWH industry. At TSL 4, the projected change in manufacturer INPV for instantaneous circulating water heaters and hot water supply boilers ranges from a decrease of $9.9 million to a decrease of $1.1

million, which corresponds to decreases of 24.3 percent and 2.7 percent, respectively. Conversion cost total $10.5 million.

At TSL 4, approximately 29 percent of instantaneous circulating water heaters and hot water supply boilers models would meet TSL 4 today. DOE notes that industry offers a large number of models to fit a wide range of installation requirements despite relatively low shipment volumes. Product conversion cost are expected to reach $8.5 million.

The Secretary concludes that at TSL 4 for CWH equipment, the benefits of energy savings, positive NPV of consumer benefits, emission reductions, and the estimated monetary value of the emissions reductions would be outweighed by the economic burden on some consumers and the impacts on manufacturers, including the potentials for large conversion costs, reduced equipment availability, delayed technology innovation, and substantial reductions in INPV. As previously noted, only one small manufacturer currently produces commercial gas-fired storage water heaters at TSL 4. Similarly, only one manufacturer currently produces residential-duty gas-fired water heaters at that level. In light of substantial conversion costs, it is unclear whether a sufficient quantity of other manufacturers would undertake the conversions necessary to offer a competitive range of products across the range of sizes and applications required for gas-fired storage water heaters. Consequently, the Secretary has concluded that the current record does not provide a clear and convincing basis to conclude that TSL 4 is economically justified.

DOE then considered TSL 3, which would save an estimated 0.70 quads of energy, an amount DOE also considers significant. Commercial gas-fired storage and storage-type instantaneous water heaters are estimated to save 0.28 quads while residential-duty gas-fired storage water heaters are estimated to save 0.13 quads of energy. Instantaneous gas-fired tankless water heaters are estimated to save 0.02 quads. Instantaneous circulating gas-fired water heaters and hot water supply boilers are estimated to save 0.26 quads of energy.

Under TSL 3, the NPV of consumer benefit would be $0.43 billion using a discount rate of 7 percent, and $1.43 billion using a discount rate of 3 percent. Benefits to consumers of commercial gas-fired storage and storage-type instantaneous equipment are estimated to be $0.32 billion using a discount rate of 7 percent, and $0.81 billion using a discount rate of 3 percent. Consumer benefits for residential-duty gas-fired storage equipment are estimated to be $0.08 billion dollars at a 7-percent discount rate and $0.27 billion at a 3-percent discount rate. Benefits to consumers of instantaneous gas-fired tankless water heaters are estimated to be $0.01 billion at a 7-percent discount rate and $0.04 billion at a 3-percent discount rate, and consumer benefits for instantaneous circulating gas-fired water heaters and hot water supply boilers are estimated to be $0.02 billion at a 7-percent discount rate and 0.30 billion at a 3-percent discount rate.

The cumulative emissions reductions at TSL 3 are 38 million metric tons of CO_2, 0.10 thousand tons of SO_2, 103 thousand tons of NO_X, -0.001 tons of Hg, 479 thousand tons of CH_4, and 0.08 thousand tons of N_2O. The estimated monetary value of the climate benefits from reduced GHG emissions reduction (associated with the average SC-GHG at a 3-percent discount rate) at TSL 3 is $2.30 billion. The estimated monetary value of the health benefits from reduced NO_X and SO_2 emissions at TSL 3 is $1.36 billion using a 7-percent discount rate and $3.29 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 $4.09 billion. Using a 3-percent discount rate for all benefits and costs, the estimated total NPV at TSL 3 is $7.02 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 of $367 for commercial gas-fired storage and storage-type instantaneous water heaters, $119 for residential-duty gas-fired storage water heaters, $120 for instantaneous gas-fired tankless water heaters, and $1,570 for instantaneous circulating water heaters and hot water supply boilers. The simple PBP is 6 years for commercial gas-fired storage water heaters, 7 years for residential-duty gas-fired storage water heaters, 9 years for instantaneous gas-fired tankless water heaters, and 9 years for instantaneous circulating water heaters and hot water supply boilers. The fraction of consumers experiencing a net LCC cost is 17 percent for commercial gas-fired storage water heaters, 42 percent for residential-duty gas-fired storage water heaters, 15 percent for instantaneous gas-fired tankless water heaters, and 18 percent for instantaneous circulating water heaters and hot water supply boilers.

At TSL 3, the projected change in manufacturer INPV ranges from a decrease of $37.6 million to a decrease of $17.7 million, which corresponds to decreases of 17.7 percent and 8.3 percent, respectively. Conversion costs total $42.7 million.

At TSL 3, nearly all commercial gas-fired storage water heaters and storage-type instantaneous equipment manufacturers have models at a range of input capacities and storage volumes that can meet 95 percent thermal efficiency. Approximately 34 percent of commercial gas-fired storage water heaters and storage-type instantaneous models currently offered would meet TSL 3 today. Additionally, an amended standard at TSL 3 would allow manufacturers to design equipment platforms that support a range of models with varying input capacities and storage volumes, rather than having to optimize designs for each individual input capacity and storage volume combinations.

The change in INPV for commercial gas-fired storage water heaters and storage-type instantaneous equipment ranges from a decrease of $23.7 million to a decrease of $17.6 million, which corresponds to decreases of 15.4 percent and 11.4 percent, respectively. Product conversion costs are $10.9 million and capital conversion costs are $16.9 million, for a total of approximately $27.8 million. At this level, product conversion costs are typical of R&D spending over the conversion period.

At TSL 3, multiple residential-duty gas-fired storage water heater manufacturers offer models at a range of input capacities and storage volumes that can meet a UEF standard at this level today. Approximately 34 percent of current residential-duty gas-fired storage water heater models would meet TSL 3. An amended standard at TSL 3 would allow manufacturers to design equipment platforms that support a range of models with varying input capacities and storage volumes, rather than having to optimize designs for each individual input capacity and storage volume combination.

The projected change in INPV for residential-duty gas-fired storage water heaters ranges from a decrease of $2.5 million to an increase of $2.2 million, which corresponds to a decrease of 27.3 percent and an increase of 25.0 percent, respectively. DOE expects conversion costs for this equipment class to reach $2.3 million.

At TSL 3, approximately 64 percent of instantaneous gas-fired tankless water heaters models would meet TSL 3 today. The projected change in manufacturer INPV for instantaneous gas-fired tankless water heaters ranges from a decrease of $1.7 million to a decrease of $1.3 million, which corresponds to decreases of 19.0 percent and 14.2 percent, respectively. Conversion costs total $2.1 million.

At TSL 3, approximately 39 percent of instantaneous circulating water heaters and hot water supply boilers models would meet TSL 3 today. The projected change in manufacturer INPV for instantaneous circulating water heaters and hot water supply boilers ranges from a decrease of $9.9 million to a decrease of $1.1 million, which corresponds to decreases of 24.3 percent and 2.7 percent, respectively. Conversion cost total $10.5 million.

After considering the analysis and weighing the benefits and burdens, the Secretary concludes that a standard set at TSL 3 for CWH equipment would be economically justified. Notably, the benefits to consumers vastly outweigh the cost to manufacturers. At TSL 3, the NPV of consumer benefits, even measured at the more conservative discount rate of 7 percent, is 1,000 percent higher than the maximum of manufacturers' loss in INPV. The positive average LCC savings—a different way of quantifying consumer benefits—reinforces this conclusion. The economic justification for TSL 3 is clear and convincing even without weighing the estimated monetary value of emissions reductions. When those emissions reductions are included—representing $2.3 billion in climate benefits (associated with the average SC-GHG at a 3-percent discount rate), and $3.3 billion (using a 3-percent discount rate) or $1.4 billion (using a 7-percent discount rate) in health benefits—the rationale becomes stronger still. DOE notes, however, that it would reach the same conclusion presented in this rule in the absence of the estimated SC-GHG benefits, based on the February 2021 Interim Estimates presented by the IWG.

As stated, DOE conducts the walk-down analysis to determine the TSL that represents the maximum improvement in energy efficiency that is technologically feasible and economically justified as required under EPCA. Although DOE has not conducted a comparative analysis to select the amended energy conservation standards, DOE notes at TSL 3 the conversion cost impacts for commercial gas storage and residential-duty gas-fired storage water heaters are less severe than TSL 4. For commercial gas storage water heaters, nearly all manufacturers have equipment that can meet TSL 3 across a range of input capacities and storage volumes. Similarly, for residential-duty commercial gas water heaters, multiple manufacturers currently produce equipment meeting TSL 3. The concerns of manufacturers being unable to offer a competitive range of equipment across the range of input capacities and storage volumes currently offered would be mitigated at TSL 3.

Although DOE considered proposed amended standard levels for CWH equipment by grouping the efficiency levels for each equipment category into TSLs, DOE evaluates all analyzed efficiency levels in its analysis. For commercial gas instantaneous water heaters (including tankless and circulating/hot water supply boilers), TSL 3 (*i.e.*, the proposed TSL) includes the max-tech efficiency levels, which is the maximum level determined to be technologically feasible. For commercial gas-fired storage water heaters and residential-duty gas-fired storage water heaters, TSL 3 includes efficiency levels that are one level below the max-tech efficiency level. As discussed previously, at the max-tech efficiency levels for gas-fired storage water heaters and residential-duty gas-fired storage water heaters there is a substantial risk of manufacturers being unable to offer a competitive range of equipment across the range of input capacities and storage volumes currently available. Setting standards at max-tech for these classes could limit other engineering and innovation efforts, such as developing heat pump water heaters for the commercial market, during the conversion period beyond compliance with amended energy conservation standards. The benefits of max-tech efficiency levels for commercial gas-fired storage water heaters and residential-duty gas-fired storage water heaters do not outweigh the negative impacts to consumers and manufacturers. Therefore, DOE concludes that the max-tech efficiency levels are not justified.

Therefore, based on the previous considerations, DOE adopts the energy conservation standards for CWH equipment at TSL 3. The amended energy conservation standards for CWH equipment, which are expressed as thermal efficiency and standby loss for commercial gas-fired storage and commercial gas-fired instantaneous water heaters and hot water supply boilers, and as UEF for residential-duty gas storage water heaters, are shown in Table V.47 and Table V.48.

Table V.47 Proposed Amended Energy Conservation Standards for Commercial Water Heating Equipment Except for Residential-Duty Commercial Water Heaters

Equipment	Size	Energy Conservation Standards*	
		Minimum Thermal Efficiency	Maximum Standby Loss†
Gas-fired storage water heaters and storage-type instantaneous water heaters	All	95%	$0.86 \times [Q/800 + 110(V_r)^{1/2}]$ (Btu/h)
Electric instantaneous water heaters‡	<10 gal	80%	N/A
	≥10 gal	77%	$2.30 + 67/V_m$ (%/h)
Gas-fired instantaneous water heaters and hot water supply boilers	<10 gal	96%	N/A
	≥10 gal	96%	$Q/800 + 110(V_r)^{1/2}$ (Btu/h)

* V_m is the measured storage volume, and V_r is the rated volume, both in gallons. Q is the nameplate input rate in Btu/h.
† Water heaters and hot water supply boilers having more than 140 gallons of storage capacity need not meet the standby loss requirement if: (1) the tank surface area is thermally insulated to R-12.5 or more, (2) a standing pilot light is not used, and (3) for gas or oil-fired storage water heaters, they have a fire damper or fan-assisted combustion.
‡ Energy conservation standards for electric instantaneous water heaters are included in EPCA. (42 U.S.C. 6313(a)(5)(D)-(E)) The compliance date for these energy conservation standards is January 1, 1994. In this final rule, DOE proposes to codify these standards for electric instantaneous water heaters in its regulations at 10 CFR 431.110. Further discussion of standards for electric instantaneous water heaters is included in section III.B.3 of this final rule.

Table V.48 Amended Energy Conservation Standards for Residential-Duty Gas-Fired Commercial Water Heaters

Equipment	Specification*	Draw Pattern**	Uniform Energy Factor
Gas-fired Storage	>75 kBtu/h and ≤105 kBtu/h and ≤120 gal and ≤180 °F	Very Small	$0.5374 - (0.0009 \times V_r)$
		Low	$0.8062 - (0.0012 \times V_r)$
		Medium	$0.8702 - (0.0011 \times V_r)$
		High	$0.9297 - (0.0009 \times V_r)$

* Additionally, to be classified as a residential-duty water heater, a commercial water heater must meet the following conditions: (1) if requiring electricity, use single-phase external power supply; and (2) the water heater must not be designed to heat water at temperatures greater than 180 °F.

Equipment	Specification*	Draw Pattern**	Uniform Energy Factor

** Draw pattern is a classification of hot water use of a consumer water heater or residential-duty commercial water heater, based upon the first-hour rating. The draw pattern is determined using the Uniform Test Method for Measuring the Energy Consumption of Water Heaters in appendix E to subpart B of 10 CFR part 430.

2. Annualized Benefits and Costs of the Adopted Standards

The benefits and costs of the proposed 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 proposed 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 benefits of GHG and NO_X emission reductions.

Table V.49 shows the annualized values for CWH equipment under TSL 3, 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 NOx and SO_2 emissions, and a 3-percent discount rate case for climate benefits from reduced GHG emissions, the estimated cost of the proposed standards for CWH equipment is $78 million per year in increased equipment costs, while the estimated annual benefits are $118 million in reduced equipment operating costs, $125 million in climate benefits, and $125 million in health benefits. In this case, the net benefit amounts to $289 million per year.

Using a 3-percent discount rate for all benefits and costs, the estimated cost of the proposed standards for CWH equipment is $72 million per year in increased equipment costs, while the estimated annual benefits are $149 million in reduced operating costs, $125 million in climate benefits, and $178 million in health benefits. In this case, the net benefit would amount to $380 million per year.

Table V.49 Annualized Benefits and Costs of Proposed Energy Conservation Standards for CWH Equipment (TSL 3)

Category	Million 2022$/year		
	Primary Estimate	Low-Net-Benefits Estimate	High-Net-Benefits Estimate
3% discount rate			
Consumer Operating Cost Savings	149	144	154
Climate Benefits*	125	124	128
Health Benefits**	178	177	197
Total Benefits†	452	445	479
Consumer Incremental Product Costs‡	72	72	74
Net Benefits	380	373	405
Change in Producer Cashflow (INPV‡‡)	(4) - (2)	(4) - (2)	(4) - (2)
7% discount rate			
Consumer Operating Cost Savings	118	115	122
Climate Benefits* (3% discount rate)	125	124	128
Health Benefits**	125	124.4	138.1
Total Benefits†	368	364	388
Consumer Incremental Product Costs‡	78	78.2	80.0
Net Benefits	289	285	308
Change in Producer Cashflow (INPV‡‡)	(4) - (2)	(4) - (2)	(4) - (2)

Category	Million 2022$/year		
	Primary Estimate	**Low-Net-Benefits Estimate**	**High-Net-Benefits Estimate**

Note: This table presents the costs and benefits associated with consumer pool heaters shipped in 2026−2055. These results include benefits to consumers which accrue after 2055 from the products shipped in 2026−2055. Numbers may not add due to rounding.
* 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). Together these represent the global social cost of greenhouse gases (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 importance and 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 $PM_{2.5}$ 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.
‡‡ 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 NIA includes all impacts (both costs and benefits) along the distribution chain beginning with the increased costs to the manufacturer to manufacture the equipment and ending with the increase in price experienced by the consumer. DOE also separately conducts a detailed analysis on the impacts on manufacturers (the 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 9.1% 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 commercial water heaters, those values are -$4 million and -$2 million. DOE accounts for that range of likely impacts in analyzing whether a TSL is economically justified. See section V.C of this document. DOE is presenting the range of impacts to the INPV under two markup 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 Markup 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 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 $376 million to $378 million at 3-percent discount rate and would range from $285 million to $287 million at 7-percent discount rate. Parentheses () indicate negative values.

VI. Procedural Issues and Regulatory Review

A. Review Under Executive Orders 12866, 13563, and 14094

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 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, 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, as amended by E.O. 14094. 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 TSD 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*). As part of the May 2022 CWH ECS NOPR, DOE prepared an IRFA. 87 FR 30722. DOE has prepared the following FRFA for the products that are the subject of this rulemaking.

1. Need For, and Objectives Of, the Rule

EPCA authorizes DOE to regulate the energy efficiency of a number of consumer products and industrial equipment. Title III, Part C of EPCA, added by Pub. L. 95-619, Title IV, section 441(a) (42 U.S.C. 6311–6317, as codified), established the Energy Conservation Program for Certain Industrial Equipment, which sets forth a variety of provisions designed to improve energy efficiency. This equipment includes the classes of CWH equipment that are the subject of this final rule. (42 U.S.C. 6311(1)(K)) EPCA prescribed energy conservation standards for CWH equipment. (42 U.S.C. 6313(a)(5))

Pursuant to EPCA, DOE is to consider amending the energy efficiency standards for certain types of commercial and industrial equipment, including the equipment at issue in this document, whenever ASHRAE amends the standard levels or design requirements prescribed in ASHRAE Standard 90.1, "Energy Standard for Buildings Except Low-Rise Residential Buildings," ("ASHRAE Standard 90.1"), and at a minimum, every 6 years. DOE must adopt the new ASHRAE efficiency level, unless DOE determines, supported by clear and convincing evidence, that adoption of a more stringent level would produce significant additional conservation of energy would be technologically feasible and economically justified. (42 U.S.C. 6313(a)(6)(A)-(C)) Not later than 2 years after a NOPR is issued, DOE must publish a final rule amending the standard. (42 U.S.C. 6313(a)(6)(C)(iii))

2. Significant Issues Raised in Response to the IRFA

DOE did not receive any comments directly commenting on the Regulatory Flexibility Analysis in response to the IRFA.

3. Description and Estimate of the Number of Small Entities Affected

For manufacturers of CWH equipment, the Small Business Administration ("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 equipment covered by this rule are classified under North American Industry Classification System ("NAICS") code 333310[184], "Commercial and Service Industry Machinery Manufacturing." In 13 CFR 121.201, the SBA sets a threshold of 1,000 employees or fewer for an entity to be considered as a small business for this category. DOE's analysis relied on publicly available databases to identify potential small businesses that manufacture equipment covered in this rulemaking. DOE utilized the CEC Modernized Appliance Efficiency Database System ("MAEDbS")[185], the DOE Energy Star Database[186], and the DOE Certification

[184] The business size standards are listed by NAICS code and industry description and are available at *www.sba.gov/document/support--table-size-standards* (Last accessed April 21, 2023)
[185] MAEDbS can be accessed at *www.cacertappliances.energy.ca.gov/Pages/Search/AdvancedSearch.aspx* (Last accessed December 19, 2022)
[186] Energy Star certified product can be found in the Energy Star database accessed at *www.energystar.gov/productfinder/product/certified-commercial-water-heaters/results* (Last accessed December 19, 2022

Compliance Database ("CCD")[187] in identifying manufacturers. For the purpose of this final rule, two analyses are being performed regarding impacts to small businesses: (1) impact of the amended standards and (2) impact of the codification of requirements for electric instantaneous water heater manufacturers.

Regarding manufacturers impacted by the amended standards, DOE identified 15 original equipment manufacturers ("OEM"). DOE screened out companies that do not meet the definition of a "small business" or are foreign-owned and operated. DOE used subscription-based business information tools to determine headcount and revenue of the small businesses. Of these 15 OEMs, DOE identified three companies that are small, domestic OEMs.

Regarding models impacted by the codification of requirements for electric instantaneous water heaters, DOE's research identified nine OEMs of commercial electric instantaneous water heaters being sold in the U.S. market. Of these nine companies, DOE has identified three as domestic, small businesses. The small businesses do not currently certify any other CWH equipment to DOE's CCD.

4. Description and Estimate of Compliance Requirements

This final rule proposes to adopt amended standards for gas-fired storage water heaters, gas-fired instantaneous water heaters and hot water supply boilers, and residential-duty gas-fired storage water heaters. Additionally, this final rule seeks to

[187] Certified equipment in the CCD are listed by product class and can be accessed at *www.regulations.doe.gov/certification-data/#q=Product_Group_s%3A** (Last accessed December 19, 2022)

codify energy conservation standards for electric instantaneous water heaters from EPCA into the CFR.

To determine the impact on the small OEMs, product conversion costs and capital conversion costs were estimated. 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 one-time investments in plant, property, and equipment made in response to new and/or amended standards. DOE's estimates of conversion costs increased between the NOPR and the final rule. As noted in section IV.J.2.c of this final rule, DOE updated its conversion cost analysis for the final rule to reflect written comments submitted in response to the NOPR and feedback received from additional manufacturer interviews conducted at the request of industry. Additionally, DOE updated its analysis to reflect changes to industry model availability that occurred between the NOPR analysis and final rule analysis. These changes result in different costs to small manufacturers between the IRFA and FRFA.

In reviewing all commercially available models in DOE's Compliance Certification Database, the three small manufacturers account for approximately 4 percent of industry model offerings. Of the three small manufacturers, the first manufacturer exclusively manufactures gas-fired instantaneous tankless water heaters and will remain unimpacted by the proposed standards as 100 percent of models meet TSL 3 or higher. There are no anticipated capital conversion costs or production conversion costs required to meet the adopted standards.

The second manufacturer exclusively manufacturers hot water supply boilers and 76 percent of its models are unimpacted by the proposed standards. DOE estimates that this manufacturer will incur approximately $50,000 in capital conversion costs and $210,000 in product conversion costs to meet proposed standards. The combined conversion costs represent less than 1 percent of the firm's estimated revenue during the conversion period.

The third manufacturer primarily manufactures gas-fired storage water heaters and residential-duty gas fired storage water heaters. For this manufacturer, 33 percent of their models are unimpacted by the proposed standards. DOE estimates that this manufacturer will incur approximately $0.6 million in capital conversion costs and $0.9 million in product conversion costs to meet proposed standards. The combined conversion costs represent approximately 4.8 percent of the firm's estimated revenue during the conversion period.

Table VI.1 Summary of Small Manufacturer Impacts

	Conversion Costs ($ millions)	Annual Revenue ($ millions)	Conversion Period Revenue ($ millions)	Conversion costs / Conversion Period Revenue
Manufacturer A	0	27	81	0.0%
Manufacturer B	0.2	219	657	0.0%
Manufacturer C	1.6	10.9	32.7	4.8%

In addition to amending standards, in this rulemaking, DOE is codifying standards for electric instantaneous CWH equipment from EPCA into the CFR.

EPCA prescribes energy conservation standards for several classes of CWH equipment manufactured on or after January 1, 1994. (42 U.S.C. 6313(a)(5)) DOE codified these standards in its regulations for CWH equipment at 10 CFR 431.110. However, when previously codifying these standards from EPCA, DOE inadvertently omitted the standards put in place by EPCA for electric instantaneous water heaters. In the final rule, DOE is codifying these standards in its regulations at 10 CFR 431.110. This final rule does not propose certification requirements for electric instantaneous water heaters. Thus, DOE estimates no additional paperwork costs on manufacturers of electric instantaneous water heater equipment as a result of the final rule.

5. Significant Alternatives to the Rule

The discussion in the previous section analyzes impacts on small businesses that would result from the adopted standards, represented by TSL 3. In reviewing alternatives to the adopted standards, DOE examined energy conservation standards set at lower efficiency levels. While TSL 1 and TSL 2 would reduce the impacts on small business manufacturers, it would come at the expense of a reduction in energy savings.

TSL 2 would save 0.49 quads of energy with the projected change in manufacturer INPV ranging from -10.6 percent to -4.4 percent. TSL 2 has energy savings that are 30 percent lower than TSL 3. TSL 1 would save 0.12 quads of energy with the projected change in manufacturer INPV ranging from -1.0 percent to less than 0.1 percent. TSL 1 has energy savings that are 83 percent lower than TSL 3.

Establishing standards at TSL 3 balances the benefits of the energy savings at TSL 3 with the potential burdens placed on CWH equipment manufacturers, including small business manufacturers. Accordingly, DOE is not adopting one of the other TSLs considered in the analysis, or 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. 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 1003 for additional details.

C. Review Under the Paperwork Reduction Act

Manufacturers of CWH equipment 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 CWH equipment, 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 CWH equipment. (*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. The 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 final 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. 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 equipment that is the subject of this final rule. States can petition DOE for exemption from such preemption to the extent, and based on criteria, set forth in EPCA. (*See* 42 U.S.C. 6316(a) and (b); 42 U.S.C. 6297.) Therefore, no further action is required by E.O. 13132.

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 if 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. Public Law 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 1 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 *www.energy.gov/sites/prod/files/gcprod/documents/umra_97.pdf.*

This rule does not contain a Federal intergovernmental mandate, nor is it expected to require expenditures of $100 million or more in any 1 year by the private sector. As a result, the analytical requirements of UMRA do not apply.

H. Review Under the Treasury and General Government Appropriations Act, 1999

Section 654 of the Treasury and General Government Appropriations Act, 1999 (Pub. L. 105-277) requires Federal agencies to issue a Family Policymaking Assessment for any rule that may affect family well-being. This rule would not have any impact on the autonomy or integrity of the family as an institution. Accordingly, DOE has concluded that it is not necessary to prepare a Family Policymaking Assessment.

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 E.O. 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 amended energy conservation standards for CWH equipment, 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 Federal 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.[188] 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.[189]

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 report will state that it has been determined that the rule is a "major rule" as defined by 5 U.S.C. 804(2).

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[188] 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 December 14, 2022).

[189] 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 in 10 CFR Part 431

Administrative practice and procedure, Confidential business information, Energy conservation test procedures, and Reporting and recordkeeping requirements.

Signing Authority

This document of the Department of Energy was signed on July 27, 2023, by Francisco Alejandro Moreno, Acting 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 July 27, 2023.

FRANCISCO MORENO

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Date: 2023.07.27 17:12:54 -04'00'

Francisco Alejandro Moreno
Acting Assistant Secretary for Energy Efficiency and Renewable Energy
U.S. Department of Energy

For the reasons set forth in the preamble, DOE amends part 431 of chapter II, subchapter D, of title 10 of the Code of Federal Regulations, to read as set forth below:

PART 431 - ENERGY EFFICIENCY PROGRAM FOR COMMERCIAL AND INDUSTRIAL EQUIPMENT

1. The authority citation for part 431 continues to read as follows:

Authority: 42 U.S.C. 6291-6317; 28 U.S.C. 2461 note.

2. Amend §431.102 by revising the definition of "Storage-type instantaneous water heater" to read as follows:

§ 431.102 Definitions concerning commercial water heaters, hot water supply boilers, unfired hot water storage tanks, and commercial heat pump water heaters.

* * * * *

Storage-type instantaneous water heater means an instantaneous water heater that includes a storage tank with a rated storage volume greater than or equal to 10 gallons.

* * * * *

3. Amend §431.105 by revising paragraph (a) to read as follows:

§431.105 Materials incorporated by reference.

(a) Certain material is incorporated by reference into this subpart with the approval of the Director of the Federal Register in accordance with 5 U.S.C. 552(a) and 1 CFR part 51. To enforce any edition other than that specified in this section, the DOE must publish a document in the Federal Register and the material must be available to the public. All approved incorporation by reference (IBR) material is available for inspection at DOE and at the National Archives and Records Administration (NARA). Contact DOE at: the U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy, Building Technologies Program, 1000 Independence Avenue SW., EE-5B, Washington, DC 20024, (202) 586-9127, *Buildings@ee.doe.gov, www.energy.gov/eere/buildings/building-technologies-office*. For information on the availability of this material at NARA, visit *www.archives.gov/federal-register/cfr/ibr-locations.html* or email: *fr.inspection@nara.gov*. The material may be obtained from the sources in the following paragraphs of this section:

* * * * *

4. Revise §431.110 to read as follows:

§431.110 Energy conservation standards and their effective dates.

(a) Each commercial storage water heater, instantaneous water heater, and hot water supply boiler (excluding residential-duty commercial water heaters) must meet the applicable energy conservation standard level(s) as specified in the table to this paragraph. Any packaged boiler that provides service water that meets the definition of “commercial packaged boiler” in subpart E of this part, but does not meet the definition of “hot water supply boiler” in subpart G of this part, must meet the requirements that apply to it under subpart E of this part.

Table 1 to § 431.110(a) – Commercial Water Heater Energy Conservation Standards

Equipment	Size	Energy Conservation Standards[a]			
		Minimum Thermal Efficiency (equipment manufactured on and after October 9, 2015)	**Minimum Thermal Efficiency (equipment manufactured on and after [INSERT DATE 3 YEARS AFTER DATE OF PUBLICATION IN THE *FEDERAL REGISTER*])**	**Maximum Standby Loss (equipment manufactured on and after October 29, 2003)[b]**	**Maximum Standby Loss (equipment manufactured on and after [INSERT DATE 3 YEARS AFTER DATE OF PUBLICATION IN THE *FEDERAL REGISTER*])[b]**
Electric storage water heaters	All	N/A	N/A	$0.30 + 27/V_m$ (%/h)	$0.30 + 27/V_m$ (%/h)
Gas-fired storage water heaters and storage-type instantaneous water heaters	All	80%	95%	$Q/800 + 110(V_r)^{1/2}$ (Btu/h)	$0.86 \times [Q/800 + 110(V_r)^{1/2}]$ (Btu/h)
Oil-fired storage water heaters	All	80%	80%	$Q/800 + 110(V_r)^{1/2}$ (Btu/h)	$Q/800 + 110(V_r)^{1/2}$ (Btu/h)
Electric instantaneous water heaters[c]	<10 gal	80%	80%	N/A	N/A
	≥10 gal	77%	77%	$2.30 + 67/V_m$ (%/h)	$2.30 + 67/V_m$ (%/h)
Gas-fired instantaneous water heaters and hot water supply boilers	<10 gal	80%	96%	N/A	N/A
	≥10 gal	80%	96%	$Q/800 + 110(V_r)^{1/2}$ (Btu/h)	$Q/800 + 110(V_r)^{1/2}$ (Btu/h)
Oil-fired instantaneous water heater and hot water supply boilers	<10 gal	80%	80%	N/A	N/A
	≥10 gal	78%	78%	$Q/800 + 110(V_r)^{1/2}$ (Btu/h)	$Q/800 + 110(V_r)^{1/2}$ (Btu/h)

[a] V_m is the measured storage volume, and V_r is the rated storage volume, both in gallons. Q is the rated input in Btu/h, as determined pursuant to 10 CFR 429.44.

[b] Water heaters and hot water supply boilers with a rated storage volume greater than 140 gallons need not meet the standby loss requirement if:

(1) The tank surface area is thermally insulated to R-12.5 or more, with the R-value as defined in §431.102

(2) A standing pilot light is not used; and

(3) For gas-fired or oil-fired storage water heaters, they have a flue damper or fan-assisted combustion.

[c] The compliance date for energy conservation standards for electric instantaneous water heaters is January 1, 1994.

(b) Each unfired hot water storage tank manufactured on and after October 29, 2003, must have a minimum thermal insulation of R-12.5.

(c) Each residential-duty commercial water heater must meet the applicable energy conservation standard level(s) as follows:

Table 2 to § 431.110(c) – Residential-Duty Commercial Water Heater Energy Conservation Standards

Equipment	Specifications[a]	Draw Pattern	Uniform energy factor[b]	
			Equipment manufactured before [INSERT DATE 3 YEARS AFTER DATE OF PUBLICATION IN THE *FEDERAL REGISTER*])	Equipment manufactured after [INSERT DATE 3 YEARS AFTER DATE OF PUBLICATION IN THE *FEDERAL REGISTER*]
Gas-fired storage	>75 kBtu/hr and ≤105 kBtu/hr and ≤120 gal	Very Small	$0.2674 - (0.0009 \times V_r)$	$0.5374 - (0.0009 \times V_r)$
		Low	$0.5362 - (0.0012 \times V_r)$	$0.8062 - (0.0012 \times V_r)$
		Medium	$0.6002 - (0.0011 \times V_r)$	$0.8702 - (0.0011 \times V_r)$
		High	$0.6597 - (0.0009 \times V_r)$	$0.9297 - (0.0009 \times V_r)$
Oil-fired storage	>105 kBtu/hr and ≤140 kBtu/hr and ≤120 gal	Very Small	$0.2932 - (0.0015 \times V_r)$	$0.2932 - (0.0015 \times V_r)$
		Low	$0.5596 - (0.0018 \times V_r)$	$0.5596 - (0.0018 \times V_r)$
		Medium	$0.6194 - (0.0016 \times V_r)$	$0.6194 - (0.0016 \times V_r)$
		High	$0.6470 - (0.0013 \times V_r)$	$0.6470 - (0.0013 \times V_r)$
Electric instantaneous	>12 kW and ≤58.6 kW and ≤2 gal	Very Small	0.80	0.80
		Low	0.80	0.80
		Medium	0.80	0.80
		High	0.80	0.80

[a] Additionally, to be classified as a residential-duty commercial water heater, a commercial water heater must meet the following conditions: (1) If the water heater requires electricity, it must use a single-phase external power supply; and (2) The water heater must not be designed to heat water to temperatures greater than 180 °F

[b] V_r is the rated storage volume (in gallons), as determined pursuant to 10 CFR 429.44.

Note: The following letter will not appear in the Code of Federal Regulations.