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[6450-01-P]

DEPARTMENT OF ENERGY

10 CFR Part 430

[EERE-2019-BT-STD-0036]

RIN 1904-AE82

Energy Conservation Program: Energy Conservation Standards for Consumer Boilers

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

ACTION: Notice of proposed rulemaking and announcement of public meeting.

SUMMARY: The Energy Policy and Conservation Act, as amended (EPCA), prescribes energy conservation standards for various consumer products and certain commercial and industrial equipment, including consumer boilers. EPCA also requires the U.S. Department of Energy (DOE or the Department) to periodically determine whether more-stringent standards would be technologically feasible and economically justified and would result in significant energy savings. In this notice of proposed rulemaking (NOPR), DOE proposes amended energy conservation standards for consumer boilers, and also announces a public meeting to receive comment on these proposed standards and associated analyses and results.

DATES: *Comments*: DOE will accept comments, data, and information regarding this NOPR no later than [**INSERT DATE 60 DAYS AFTER DATE OF PUBLICATION IN THE *FEDERAL REGISTER***].

Meeting: DOE will hold a public meeting via webinar on Tuesday, September 12, 2023 from 1:00 p.m. to 4:00 p.m. See section VII, "Public Participation," for webinar registration information, participant instructions and information about the capabilities available to webinar participants.

Comments regarding the likely competitive impact of the proposed standard should be sent to the Department of Justice contact listed in the **ADDRESSES** section on or before [**INSERT DATE 30 DAYS AFTER DATE OF PUBLICATION IN THE *FEDERAL REGISTER***].

ADDRESSES: Interested persons are encouraged to submit comments using the Federal eRulemaking Portal at *www.regulations.gov* under docket number EERE–2019–BT–STD-0036. Follow the instructions for submitting comments. Alternatively, interested persons may submit comments, identified by docket number EERE-2019-BT-STD-0036 and/or RIN 1904-AE82, by any of the following methods:

Email: *ConsumerBoilers2019STD0036@ee.doe.gov*. Include the docket number EERE-2019-BT-STD-0036 and/or RIN 1904-AE82 in the subject line of the message.

Postal Mail: Appliance and Equipment Standards Program, U.S. Department of Energy, Building Technologies Office, Mailstop EE-5B, 1000 Independence Avenue, SW., Washington, DC, 20585-0121. If possible, please submit all items on a compact disc (CD), in which case it is not necessary to include printed copies.

Hand Delivery/Courier: Appliance and Equipment Standards Program, U.S. Department of Energy, Building Technologies Office, 950 L'Enfant Plaza, SW., 6th Floor, Washington, DC, 20024. Telephone: (202) 287-1445. If possible, please submit all items on a CD, in which case it is not necessary to include printed copies.

No telefacsimiles (faxes) will be accepted. For detailed instructions on submitting comments and additional information on this process, see section VII (Public Participation) of this document.

Docket: The docket for this activity, which includes *Federal Register* notices, 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-2019-BT-STD-0036*. The docket webpage contains instructions on how to access all documents, including public comments, in the docket. See section VII (Public Participation) of this document for information on how to submit comments through *www.regulations.gov*.

EPCA requires the Attorney General to provide DOE a written determination of whether the proposed standard is likely to lessen competition. The U.S. Department of Justice Antitrust Division invites input from market participants and other interested persons with views on the likely competitive impact of the proposed standard for consumer boilers. Interested persons may contact the Division at *energy.standards@usdoj.gov* on or before the date specified in the **DATES** section. Please indicate in the "Subject" line of your email the title and Docket Number of this proposed rulemaking.

FOR FURTHER INFORMATION CONTACT: Ms. Julia Hegarty, U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy, Building Technologies

Office, EE-5B, 1000 Independence Avenue, SW., Washington, DC, 20585-0121. Telephone: (240) 597-6737. Email: *ApplianceStandardsQuestions@ee.doe.gov*.

Mr. Eric Stas, U.S. Department of Energy, Office of the General Counsel, GC-33, 1000 Independence Avenue, SW., Washington, DC, 20585-0121. Telephone: (202) 586-5827. Email: *Eric.Stas@hq.doe.gov*.

For further information on how to submit a comment, review other public comments and the docket, or participate in the public meeting webinar, contact the Appliance and Equipment Standards Program staff at (202) 287-1445 or by email: *ApplianceStandardsQuestions@ee.doe.gov*.

SUPPLEMENTARY INFORMATION:

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I. Synopsis of the Proposed Rule

The Energy Policy and Conservation Act, as amended (EPCA),[1] Pub. L. 94-163 (codified at 42 U.S.C. 6291-6317), authorizes DOE to regulate the energy efficiency of a number of consumer products and certain industrial equipment. (42 U.S.C. 6291–6317) Title III, Part B[2] of EPCA established the Energy Conservation Program for Consumer Products Other Than Automobiles. (42 U.S.C. 6291–6309) These products include consumer boilers, the subject of this rulemaking. (42 U.S.C. 6292(a)(5))[3]

Pursuant to EPCA, any new or amended energy conservation standard must be designed to achieve the maximum improvement in energy efficiency that DOE determines is technologically feasible and economically justified. (42 U.S.C. 6295(o)(2)(A)) Furthermore, the new or amended standard must result in a significant conservation of energy. (42 U.S.C. 6295(o)(3)(B)) EPCA also provides that not later than six years after issuance of any final rule establishing or amending a standard, DOE must publish either a notice of determination that standards for the product do not need to be amended, or a notice of proposed rulemaking including new proposed energy conservation standards (proceeding to a final rule, as appropriate). (42 U.S.C. 6295(m)(1))

In accordance with these and other statutory provisions discussed in this document, DOE analyzed the benefits and burdens of four trial standard levels (TSLs) for consumer boilers. The TSLs and their associated benefits and burdens are discussed in

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[1] All references to EPCA in this document refer to the statute as amended through the Energy Act of 2020, Pub. L. 116-260 (Dec. 27, 2020), which reflect the last statutory amendments that impact Parts A and A-1 of EPCA.

[2] For editorial reasons, upon codification in the U.S. Code, Part B was redesignated Part A.

[3] DOE notes that consumer boilers are defined as a subcategory of covered consumer furnaces (*see* 42 U.S.C. 6291(23)).

detail in sections V.A-C of this document. As discussed in section V.C of this document, DOE has tentatively determined that TSL 3 represents the maximum improvement in energy efficiency that is technologically feasible and economically justified. The proposed standards at TSL 3, which are expressed in minimum annual fuel utilization efficiency (AFUE), standby mode power consumption ($P_{W,SB}$) and off mode power consumption ($P_{W,OFF}$), are shown in Table I.1. These proposed standards, if adopted, would apply to all consumer boilers listed in Table I.1 manufactured in, or imported into, the United States starting on the date five years after the date of publication of the final rule for this rulemaking. Specifically, DOE is proposing more-stringent AFUE standards for gas-fired and oil-fired boilers while maintaining the current standards for electric steam and hot water boilers. Additionally, DOE is proposing to maintain the design requirements and exceptions to the minimum AFUE requirements established by statute and currently codified at 10 CFR 430.32(e)(2). (*See* 42 U.S.C. 6295(f)(3)(A)-(C))

Table I.1 Proposed Energy Conservation Standards for Consumer Boilers

Product Class	AFUE (%)*	$P_{W,SB}$ (W)*	$P_{W,OFF}$ (W)*	Design Requirements*
Gas-fired Hot Water	95	9	9	Constant-burning pilot not permitted. Automatic means for adjusting water temperature required (except for boilers equipped with tankless domestic water heating coils).
Gas-Fired Steam	82	8	8	Constant-burning pilot not permitted.
Oil-fired Hot Water	88	11	11	Automatic means for adjusting temperature required (except for boilers equipped with tankless domestic water heating coils).
Oil-fired Steam	86	11	11	None.
Electric Hot Water	None	8	8	Automatic means for adjusting temperature required (except for boilers equipped with tankless domestic water heating coils).
Electric Steam	None	8	8	None.

* A boiler that is manufactured to operate without any need for electricity or any electric connection, electric gauges, electric pumps, electric wires, or electric devices is not required to meet the AFUE, $P_{W,SB}$, $P_{W,OFF}$, or design

requirements, but must meet the requirements of 10 CFR 430.32(e)(2)(i) which include a minimum AFUE of 75 percent for gas-fired steam boilers and a minimum AFUE of 80 percent for all other boilers.

A. Benefits and Costs to Consumers

Table I.2 presents DOE's evaluation of the economic impacts of the proposed standards on consumers of consumer boilers, as measured by the average life-cycle cost (LCC) savings and the simple payback period (PBP).[4] The average LCC savings are positive for all product classes, and the PBP is less than the average lifetime of consumer boilers, which is estimated to be 26.9 years for gas-fired hot water boilers, 23.7 years for gas-fired steam boilers, 25.6 years for oil-fired hot water boilers, and 19.6 years for oil-fired steam boilers (see section IV.F.6 of this document for further details).

Table I.2 Impacts of Proposed Energy Conservation Standards on Consumers of Consumer Boilers

Product Class	Average LCC Savings *(2022$)*	Simple Payback Period *(years)*
Gas-fired Hot Water	768	2.7
Gas-fired Steam	-	-
Oil-fired Hot Water	666	3.3
Oil-fired Steam	310	5.5

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

[4] The average LCC savings refer to consumers that are affected by a standard and are measured relative to the distribution of purchased boilers, and their associated energy efficiency, 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.C of this document).

B. Impact on Manufacturers[5]

The industry net present value (INPV) is the sum of the discounted cash flows starting from the publication year (2023) of the NOPR and continuing through the 30-year period following the expected compliance date of the standards (2023–2059). Using a real discount rate of 9.7 percent, DOE estimates that the INPV for manufacturers of consumer boilers in the case without amended standards is $532.0 million. Under the proposed standards, the change in INPV is estimated to range from -11.7 percent to -7.7 percent, which is approximately -$62.2 million to -$40.7 million. In order to bring products into compliance with amended standards, it is estimated that the industry would incur total conversion costs of $98.0 million.

DOE's analysis of the impacts of the proposed 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

DOE's analyses indicate that the proposed energy conservation standards for consumer boilers would save a significant amount of energy. Relative to the case without amended standards, the lifetime energy savings for consumer boilers purchased in the 30-year period that begins in the anticipated year of compliance with the amended standards (2030–2059) amount to 0.7 quadrillion British thermal units (Btu), or quads.[6] This represents a savings of 2.3 percent relative to the energy use of these products in the case

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

without amended standards (referred to as the "no-new-standards case" or as the baseline).

The cumulative net present value (NPV) of total consumer benefits of the proposed standards for consumer boilers ranges from \$0.72 billion (at a 7-percent discount rate) to \$2.27 billion (at a 3-percent discount rate). This NPV expresses the estimated total value of future operating-cost savings minus the estimated increased product and installation costs for consumer boilers purchased in 2030–2059 relative to the baseline.

In addition, the proposed standards for consumer boilers are projected to yield significant environmental benefits. DOE estimates that the proposed standards would result in cumulative emission reductions (over the same period as for energy savings) of 39 million metric tons (Mt)[7] of carbon dioxide (CO_2), 438 thousand tons of methane (CH_4), 0.17 thousand tons of nitrous oxide (N_2O), 105 thousand tons of nitrogen oxides (NO_X), and 2.7 thousand tons of sulfur dioxide (SO_2), and an increase of 0.001 tons of mercury (Hg) due to slightly higher electricity consumption.[8]

DOE estimates the value of climate benefits from a reduction in greenhouse gases (GHG) using four different estimates of the social cost of CO_2 (SC-CO_2), the social cost of methane (SC-CH_4), and the social cost of nitrous oxide (SC-N_2O). Together these represent the social cost of GHG (SC-GHG). DOE used interim SC-GHG values developed by an Interagency Working Group on the Social Cost of Greenhouse Gases

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

[8] DOE calculated emissions reductions relative to the no-new-standards case, which reflects key assumptions in the *Annual Energy Outlook 2023* (*AEO 2023*). *AEO 2023* represents current Federal and State legislation and final implementation of regulations as of the time of its preparation. See section IV.K of this document for further discussion of *AEO2023* assumptions that effect air pollutant emissions.

(IWG).[9] The derivation of these values is discussed in section IV.L of this document. For presentational purposes, the climate benefits associated with the average SC-GHG at a 3-percent discount rate over the period of analysis are estimated to be $2.0 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 sets of SC-GHG estimates.

DOE estimated the monetary health benefits of SO_2 and NO_X emissions reductions using benefit per ton estimates from the scientific literature, as discussed in section IV.L of this document. DOE estimated the present value of the health benefits would be $1.1 billion using a 7-percent discount rate, and $3.3 billion using a 3-percent discount rate.[10] DOE is currently only monetizing (for SO_2 and NO_X) health benefits from changes in fine particulate matter ($PM_{2.5}$) precursors (SO_2 and NO_X) and for changes in an ozone precursor (NO_X), but will continue to assess the ability to monetize other effects such as health benefits from reductions in direct $PM_{2.5}$ emissions.

Table I.3 summarizes the monetized benefits and costs expected to result from the proposed standards for consumer boilers. 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.

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[9] To monetize the benefits of reducing GHG emissions this analysis uses the interim estimates presented in the *Technical Support Document: Social Cost of Carbon, Methane, and Nitrous Oxide Interim Estimates Under Executive Order 13990* published in February 2021 by the IWG. ("February 2021 SC-GHG TSD"). www.whitehouse.gov/wp-content/uploads/2021/02/TechnicalSupportDocument_SocialCostofCarbonMethaneNitrousOxide.pdf.

[10] DOE estimates the economic value of these emissions reductions resulting from the considered trial standard levels (TSLs) for the purpose of complying with the requirements of Executive Order 12866.

Table I.3 Present Value of Monetized Benefits and Costs of Proposed Energy Conservation Standards for Consumer Boilers (TSL 3)

	Billion 2022$
3% discount rate	
Consumer Operating Cost Savings	3.1
Climate Benefits*	2.0
Health Benefits**	3.3
Total Monetized Benefits†	8.5
Consumer Incremental Product Costs‡	0.8
Net Monetized Benefits	7.6
Change in Producer Cashflow (INPV‡‡)	(0.06) – (0.04)
7% discount rate	
Consumer Operating Cost Savings	1.1
Climate Benefits* (3% discount rate)	2.0
Health Benefits**	1.1
Total Monetized Benefits†	4.3
Consumer Incremental Product Costs‡	0.4
Net Monetized Benefits	3.9
Change in Producer Cashflow (INPV‡‡)	(0.06) – (0.04)

Note: This table presents present value (in 2022$) of the costs and benefits associated with consumer boilers shipped in 2030−2059. These results include benefits which accrue after 2059 from the products shipped in 2030−2059.

* Climate benefits are calculated using four different estimates of the social cost of carbon (SC-CO_2), methane (SC-CH_4), and nitrous oxide (SC-N_2O) (model average at 2.5-percent, 3-percent, and 5-percent discount rates; 95th percentile at 3-percent discount rate) (see section IV.L of this document). 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 (for SO_2 and NO_X) $PM_{2.5}$ precursor health benefits and (for NO_X) ozone precursor health benefits, but will continue to assess the ability to monetize other effects such as health benefits from reductions in direct $PM_{2.5}$ emissions. *See* section IV.L of this document for more details.

† Total and net benefits include those consumer, climate, and health benefits that can be quantified and monetized. For presentation purposes, total and net benefits for both the 3-percent and 7-percent cases are presented using the average SC-GHG with 3-percent discount rate, but DOE does not have a single central

SC-GHG point estimate. DOE emphasizes the importance and value of considering the benefits calculated using all four sets of SC-GHG estimates.
‡ 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 product 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 9.7 percent that is estimated in the manufacturer impact analysis (see chapter 12 of the NOPR TSD for a complete description of the industry weighted average cost of capital). For consumer boilers, those values are -$62 million and -$41 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, to provide additional context for assessing the estimated impacts of this proposal 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 proposed rule, the net benefits would range from $7.54 billion to $7.56 billion at 3-percent discount rate and would range from $3.84 billion to $3.86 billion at 7-percent discount rate. DOE seeks comment on this approach.

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

[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. 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.

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

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

Using a 7-percent discount rate for consumer benefits and costs and health benefits from reduced NO_X and SO_2 emissions, and the 3-percent discount rate case for climate benefits from reduced GHG emissions, the estimated monetized cost of the standards proposed in this rule is $52 million per year in increased equipment costs, while the estimated annual benefits are $139 million in reduced equipment operating costs, $124 million in monetized climate benefits, and $137 million in monetized health benefits. In this case, the net monetized benefit would amount to $348 million per year.

Using a 3-percent discount rate for all benefits and costs, the estimated monetized cost of the proposed standards is $50 million per year in increased equipment costs, while the estimated annual monetized benefits are $188 million in reduced operating costs, $124 million in monetized climate benefits, and $204 million in in monetized air pollutant health benefits. In this case, the net benefit would amount to $466 million per year.

Table I.4 Annualized Monetized Benefits and Costs of Proposed Energy Conservation Standards for Consumer Boilers (TSL 3)

	Million 2022$/year		
	Primary Estimate	**Low-Net-Benefits Estimate**	**High-Net-Benefits Estimate**
	3% discount rate		
Consumer Operating Cost Savings	188	175	233
Climate Benefits*	124	121	144
Health Benefits**	204	200	237
Total Monetized Benefits†	516	496	613
Consumer Incremental Product Costs‡	50	58	38
Net Monetized Benefits	466	438	575
Change in Producer Cashflow (INPV‡‡)	(6) - (4)	(6) - (4)	(6) - (4)
	7% discount rate		
Consumer Operating Cost Savings	139	129	169
Climate Benefits* (3% discount rate)	124	121	144
Health Benefits**	137	135	158
Total Monetized Benefits†	400	385	470
Consumer Incremental Product Costs‡	52	59	41
Net Monetized Benefits	348	326	430
Change in Producer Cashflow (INPV‡‡)	(6) - (4)	(6) - (4)	(6) - (4)

Note: This table presents the present value (in 2022$) of the costs and benefits associated with consumer boilers shipped in 2030–2059. These results include benefits which accrue after 2059 from the products shipped in 2030–2059. The Primary, Low-Net-Benefits, and High-Net-Benefits Estimates utilize projections of energy prices from the *AEO 2023* Reference case, Low-Economic-Growth case, and High-Economic-Growth case, respectively. In addition, incremental equipment costs reflect a constant trend in the Primary Estimate, an increasing rate in the Low-Net-Benefits Estimate, and a decreasing rate in the High-Net-Benefits Estimate. The methods used to derive projected price trends are explained in sections

IV.F.1 and IV.H.3 of this document. Note that the Benefits and Costs may not sum to the Net Benefits due to rounding.
* Climate benefits are calculated using four different estimates of the global SC-GHG (see section IV.L of this document). 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 (for SO_2 and NO_X) $PM_{2.5}$ precursor health benefits and (for NO_X) ozone precursor health benefits, but will continue to assess the ability to monetize other effects such as health benefits from reductions in direct $PM_{2.5}$ emissions. See section IV.L of this document for more details.
† Total benefits for both the 3-percent and 7-percent cases are presented using the average SC-GHG with 3-percent discount rate, but the Department does not have a single central SC-GHG point estimate.
‡ 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 product 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 9.7 percent that is estimated in the manufacturer impact analysis (see chapter 12 of the NOPR TSD for a complete description of the industry weighted average cost of capital). For consumer boilers, those values are -$6 million and -$4 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 proposal 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 proposed rule, the annualized net benefits would range from $460 million to $462 million at 3-percent discount rate and would range from $342 million to $344 million at 7-percent discount rate. DOE seeks comment on this approach.

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

D. Conclusion

DOE has tentatively concluded that the proposed standards represent the maximum improvement in energy efficiency that is technologically feasible and economically justified, and would result in the significant conservation of energy. Specifically, with regards to technological feasibility, products achieving these standard levels are already commercially available for all product classes covered by this proposal. As for economic justification, DOE's analysis shows that the benefits of the proposed standard exceed, to a great extent, the burdens of the proposed 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 consumer boilers is $52 million per year from increased consumer boiler costs, while the estimated annual monetized benefits are $139 million in reduced consumer boiler operating costs, $124 million in monetized climate benefits, and $137 million in monetized air pollutant health benefits. The net monetized benefit amounts to $348 million per year.

The significance of energy savings offered by a new or amended energy conservation standard cannot be determined without knowledge of the specific circumstances surrounding a given rulemaking.[12] For example, some covered products and equipment have substantial energy consumption occur during periods of peak energy demand. The impacts of these products on the energy infrastructure can be more

[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).

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 proposed standards are projected to result in estimated national energy savings of 0.7 quads full-fuel-cycle (FFC), the equivalent of the primary annual energy use of 6.5 million homes, and NPV of total consumer benefits from $0.72 billion (at a 7-percent discount rate) to $2.27 billion (at a 3-percent discount rate) over the 30-year analysis period beginning with the expected compliance year (2030–2059). In addition, they are projected to reduce CO_2 emissions by 44 Mt. Based on these findings, DOE has initially determined the energy savings from the proposed standard levels are "significant" within the meaning of 42 U.S.C. 6295(o)(3)(B). A more detailed discussion of the basis for these tentative conclusions is contained in the remainder of this document and the accompanying technical support document (TSD).[13]

DOE also considered more-stringent energy efficiency levels as potential standards, and is still considering them in this rulemaking. However, DOE has tentatively concluded that the potential burdens of the more-stringent energy efficiency levels would outweigh the projected benefits.

Based on consideration of the public comments DOE receives in response to this document and related information collected and analyzed during the course of this rulemaking effort, DOE may adopt energy efficiency levels presented in this document

[13] The TSD is available in the docket for this rulemaking at: *www.regulations.gov/docket/EERE-2019-BT-STD-0036*.

that are either higher or lower than the proposed standards, or some combination of level(s) that incorporate the proposed standards in part.

II. Introduction

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

A. Authority

EPCA, Pub. L. 94-163 (codified at 42 U.S.C. 6291-6317) authorizes DOE to regulate the energy efficiency of a number of consumer products and certain industrial equipment. Title III, Part B of EPCA established the Energy Conservation Program for Consumer Products Other Than Automobiles. (42 U.S.C. 6291-6309) These products include consumer boilers, the subject of this document. (42 U.S.C. 6292(a)(5))

EPCA prescribed energy conservation standards for these products (42 U.S.C. 6295(f)(3)), and the statute directed DOE to conduct future rulemakings to determine whether to amend these standards. (42 U.S.C. 6295(f)(4)(C)) EPCA further provides that, not later than six years after the issuance of any final rule establishing or amending a standard, DOE must publish either a notice of determination that standards for the product do not need to be amended, or a NOPR including new proposed energy conservation standards (proceeding to a final rule, as appropriate). (42 U.S.C. 6295(m)(1))

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

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

Subject to certain criteria and conditions, DOE is required to develop test procedures to measure the energy efficiency, energy use, or estimated annual operating cost of each covered product. (42 U.S.C. 6295(o)(3)(A) and 6295(r)) Manufacturers of covered products must use the prescribed DOE test procedure as the basis for certifying to DOE that their products comply with the applicable energy conservation standards adopted under EPCA and when making representations to the public regarding the energy use or efficiency of those products. (42 U.S.C. 6293(c) and 42 U.S.C. 6295(s)) Similarly, DOE must use these test procedures to determine whether the products comply with standards adopted pursuant to EPCA. (42 U.S.C. 6295(s)) The DOE test procedures for consumer boilers appear at title 10 of the Code of Federal Regulations (CFR) part 430, subpart B, appendix EE.[14]

[14] On March 13, 2023, DOE published a final rule in the *Federal Register* amending the test procedure for consumer boilers and moving this test procedure to a new appendix EE effective on April 12, 2023. 88 FR 15510.

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

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

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

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

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

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

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

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

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

(42 U.S.C. 6295(o)(2)(B)(i)(I)–(VII))

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

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

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

Finally, pursuant to the amendments contained in the Energy Independence and Security Act of 2007 (EISA 2007), Pub. L. 110-140, any final rule for new or amended energy conservation standards promulgated after July 1, 2010, is required to address standby mode and off mode energy use. (42 U.S.C. 6295(gg)(3)) Specifically, when DOE adopts a standard for a covered product after that date, it must, if justified by the criteria for adoption of standards under EPCA (42 U.S.C. 6295(o)), incorporate standby mode and off mode energy use into a single standard, or, if that is not feasible, adopt a separate standard for such energy use for that product. (42 U.S.C. 6295(gg)(3)(A)–(B)) DOE's current test procedures for consumer boilers address standby mode and off mode energy use in separate metrics ($P_{W,SB}$ and $P_{W,OFF}$, respectively). In this proposed rulemaking, DOE intends to consider these metrics in addition to the active mode metric, AFUE.

B. Background

1. Current Standards

In a final rule published in the *Federal Register* on January 15, 2016 (January 2016 Final Rule), DOE prescribed the current energy conservation standards for consumer boilers manufactured on and after January 15, 2021. 81 FR 2320, 2416–2417. These standards are set forth in DOE's regulations at 10 CFR 430.32(e)(2)(iii) and are repeated in Table II.1.

Table II.1 Federal Energy Conservation Standards for Consumer Boilers*

Product Class	**AFUE (*percent*)****	**$P_{W,SB}$ (*watts*)**†	**$P_{W,OFF}$ (*watts*)** †	**Design Requirements**
Gas-fired Hot Water	84	9	9	Constant-burning pilot not permitted. Automatic means for adjusting water temperature required (except for boilers equipped with tankless domestic water heating coils).
Gas-fired Steam	82	8	8	Constant-burning pilot not permitted.
Oil-fired Hot Water	86	11	11	Automatic means for adjusting temperature required (except for boilers equipped with tankless domestic water heating coils).
Oil-fired Steam	85	11	11	None.
Electric Hot Water	None	8	8	Automatic means for adjusting temperature required (except for boilers equipped with tankless domestic water heating coils).
Electric Steam	None	8	8	None.

*A boiler that is manufactured to operate without any need for electricity or any electric connection, electric gauges, electric pumps, electric wires, or electric devices is not required to meet the AFUE or design requirements. Instead, such boilers must meet a minimum AFUE of 80 percent (for all classes except gas-fired steam), and 75 percent for gas-fired steam.
**AFUE stands for Annual Fuel Utilization Efficiency, as determined in 10 CFR 430.23(n)(2).
† $P_{W,SB}$ and $P_{W,OFF}$ stand for standby mode power consumption and off mode power consumption, respectively.

2. History of Standards Rulemaking for Consumer Boilers

DOE initiated this rulemaking pursuant to its six-year-lookback authority under 42 U.S.C. 6295(m)(1). On March 25, 2021, DOE published in the *Federal Register* a request for information (RFI) that initiated an early assessment review to determine whether any new or amended standards would satisfy the relevant requirements of EPCA for a new or amended energy conservation standard for consumer boilers (March 2021 RFI). 86 FR 15804. Specifically, through the March 2021 RFI, DOE sought data and information that could enable the agency to determine whether DOE should propose a "no new standard" determination because a more-stringent standard: (1) would not result in a significant savings of energy; (2) is not technologically feasible; (3) is not economically justified; or (4) any combination of foregoing. *Id.* Additionally, DOE granted a 30-day comment extension for the March 2021 RFI (for a total of a 60-day comment period) in a notice published in the *Federal Register* on April 9, 2021. 86 FR 18478, 18479.

Subsequently, on May 4, 2022, DOE published in the *Federal Register* a preliminary analysis and TSD for purposes of evaluating the need for amended energy conservation standards for consumer boilers (May 2022 Preliminary Analysis). 87 FR 26304. The May 2022 Preliminary Analysis and TSD discussed the analytical framework, models, and tools used to evaluate potential standards, and the results of the preliminary analyses performed. *Id.* DOE held a public meeting webinar on June 16, 2022, to receive comments on its May 2022 Preliminary Analysis for consumer boilers.

DOE received comments in response to the May 2022 Preliminary Analysis from the interested parties listed in Table II.2.

Table II.2 May 2022 Preliminary Analysis Written Comments*

Commenter(s)	Abbreviation	Comment No. in the Docket	Commenter Type
American Gas Association, American Public Gas Association, National Propane Gas Association	AGA, APGA, and NPGA	38	Utility Trade Associations
Air-Conditioning, Heating, and Refrigeration Institute	AHRI	40, 42	Manufacturer Trade Association
Bradford White Corporation	BWC	39	Manufacturer
Crown Boiler Company	Crown	30	Manufacturer
Appliance Standards Awareness Project, American Council for an Energy-Efficient Economy, Consumer Federation of America, National Consumer Law Center, Natural Resources Defense Council	Joint Advocates	35	Efficiency Advocacy Organizations
Northwest Energy Efficiency Alliance	NEEA	36	Efficiency Advocacy Organization
New York State Energy Research and Development Authority	NYSERDA	33	State Agency
PB Heat, LLC.	PB Heat	34	Manufacturer
Rheem Manufacturing Company	Rheem	37	Manufacturer
U.S. Boiler Company, Inc.	U.S. Boiler	31	Manufacturer
Weil-McLain Technologies	WMT	32	Manufacturer

* DOE received one additional comment to this docket that was not accessible and is not discussed further.

A parenthetical reference at the end of a comment quotation or paraphrase provides the location of the item in the public record.[15] To the extent that interested parties have provided written comments that are substantively consistent with any oral comments provided during the June 16, 2022 Preliminary Analysis public meeting webinar, DOE cites the written comments throughout this document.

C. Deviation from Appendix A

In accordance with section 3(a) of 10 CFR part 430, subpart C, appendix A (appendix A), DOE notes that it deviated from the provision at section 6(a)(2) in

[15] The parenthetical reference provides a reference for information located in the docket of DOE's rulemaking to develop energy conservation standards for consumer boilers. (Docket No. EERE-2019-BT-STD-0036, which is maintained at *www.regulations.gov*). The references are arranged as follows: (commenter name, comment docket ID number, page of that document).

appendix A regarding the pre-NOPR stages for an energy conservation standards rulemaking (specifically, the publication of a framework document). As initially discussed in the May 2022 Preliminary Analysis, DOE opted to deviate from this step by publishing a preliminary analysis without a framework document. A framework document is intended to introduce and summarize the various analyses DOE conducts during the rulemaking process and requests initial feedback from interested parties. As noted in the May 2022 Preliminary Analysis, prior to that document, DOE published an RFI in the *Federal Register* in which DOE identified and sought comment on the analyses conducted in support of the most recent energy conservation standards rulemakings for boilers. 87 FR 26304, 26307 (May 4, 2022).

In accordance with section 3(a) of appendix A, DOE notes that it is deviating from the provision in appendix A specifying that there will not be less than 75 days for public comment on the NOPR (section 6(f)(2) of appendix A). The public comment period on this NOPR will be 60 days. DOE is opting to deviate from this step because the May 2022 Preliminary Analysis already allowed stakeholders an opportunity to comment on the analytical methods and subsequent preliminary results. Additionally, DOE extended the comment period for the March 2021 RFI by 30 days for a total of a 60-day comment period. 86 FR 18478, 18479 (April 9, 2021). This NOPR relies on the same overall approach, but has updated the analyses to incorporate stakeholder feedback in response to the preliminary results. Consequently, DOE has concluded that that a comment period of 60 days is appropriate and will provide interested parties a meaningful opportunity to comment on the proposed rule.

DOE notes that it is not deviating from the provisions in section 8(d)(1) of appendix A, which state that a test procedure final rule should be published at least 180 days prior to the close of a comment period of a NOPR proposing amended standards for the products within the scope of the test procedure final rule. Specifically, section 8(d)(1) pertains to test procedure amendments that impact measured energy use or efficiency. Most recently, DOE published a test procedure final rule in the *Federal Register* on March 13, 2023. 88 FR 15510. In this final rule, DOE concluded that the updates to the test procedure have minimal impact on AFUE ratings and that manufacturers will be able to rely on data generated under the previous version of that test procedure. Thus, an analysis of potential amended energy conservation standards for consumer boilers can be carried out using current performance data, so the 180-day requirement does not apply.

III. General Discussion

DOE developed this proposal 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.

AGA, APGA, and NPGA requested that DOE host a workshop to walk through the Department's analytical approach for stakeholders and the public in general, because these commenters suggested that the TSDs and associated spreadsheets are complex and appear not to be consistent across product categories. (AGA, APGA, NPGA, No. 38 at p. 4)

In response, DOE notes that the Department posts its TSDs and spreadsheet analyses to the rulemaking docket found at *regulations.gov* in order to provide transparency into the methodology used to arrive at the results presented in this NOPR. As stated in the **DATES** section of this proposed rule, DOE will host a public meeting via webinar which will include an overview of DOE's methodology and provide an opportunity for stakeholders to provide additional comments or pose questions on this topic.

Crown and U.S. Boiler stated that a 60-day comment period was insufficient to review the May 2022 Preliminary Analysis, given that several calculations and underlying assumptions have changed since the previous rulemaking. (Crown, No. 30 at p. 2; U.S. Boiler, No. 31 at p. 1)

As explained in the May 2022 Preliminary Analysis, DOE opted to provide a 60-day comment period because the Department had already requested comment in the March 2021 RFI on its energy conservation standards analyses. DOE incorporated then most recent data inputs but largely relied on many of the same analytical assumptions and approaches used in the previous rulemaking, such that the agency determined that a 60-day comment period in conjunction with the prior comment period for the March 2021 RFI provided sufficient time for interested parties to review the preliminary analysis and develop comments. 87 FR 26304, 26307 (May 4, 2022). Further, DOE notes that it is providing an additional 60-day comment period for this NOPR, which again relies on the same analytical structure as the May 2022 Preliminary Analysis.

B. Scope of Coverage

Consumer boilers are appliances that transfer heat using combustion gases or electricity to water to provide hot water or steam for space heating.

Consumer boilers are defined in EPCA as a type of furnace. Specifically, the term "furnace" is defined as a product which utilizes only single-phase electric current, or single-phase electric current or direct current in conjunction with natural gas, propane, or home heating oil, and which—

Is designed to be the principal heating source for the living space of a residence;

Is not contained within the same cabinet with a central air conditioner whose rated cooling capacity is above 65,000 Btu per hour (Btu/h);

Is an electric central furnace, electric boiler, forced-air central furnace, gravity central furnace, or low pressure steam or hot water boiler; and

Has a heat input rate of less than 300,000 Btu/h for electric boilers and low pressure steam or hot water boilers and less than 225,000 Btu/h for forced-air central furnaces, gravity central furnace, and electric central furnaces. (42 U.S.C. 6291(23))

DOE has codified definitions for the terms "electric boiler" and "low pressure steam or hot water boiler" in its regulations as follows:

Electric boiler means an electrically powered furnace designed to supply low pressure steam or hot water for space heating application. A low pressure steam boiler operates at or below 15 pounds per square inch gauge (psig) steam pressure; a hot water boiler operates at or below 160 psig water pressure and 250 degrees Fahrenheit (°F) water temperature.

Low pressure steam or hot water boiler means an electric, gas, or oil-burning furnace designed to supply low pressure steam or hot water for space heating application. A low pressure steam boiler operates at or below 15 psig steam pressure; a hot water boiler operates at or below 160 psig water pressure and 250 °F water temperature.

10 CFR 430.2.

In the May 2022 Preliminary Analysis, DOE requested comment on hydronic heat pumps as technology options for consumer boilers. (*See* the Executive Summary of the preliminary analysis TSD). In response, the Department received multiple comments regarding the classification of hydronic heat pump boilers. Hydronic heat pumps, commonly air-to-water heat pumps, are systems that use the refrigeration cycle to heat or chill water for domestic hot water or space conditioning use.

Crown and U.S. Boiler stated that heat pumps should not be classified as boilers due to their inability to generate water temperatures high enough to satisfy the design heating load of the vast majority of the residential hot water heating systems in the United States. (Crown, No. 30 at p. 3; U.S. Boiler, No. 31 at p. 3) BWC also disagreed with DOE's interpretation in the May 2022 Preliminary Analysis that air-to-water and water-to-water heat pumps (heat pump products) should be considered as consumer boilers, stating that heat pump products have pronounced differences that separate them from boilers. BWC also claimed that DOE has listed the two products separately on their website, as well as in DOE's Compliance Certification Management System (CCMS) database. (BWC, No. 39 at p. 1) AHRI similarly commented that heat pumps should not be included under the current regulatory definitions for boilers and boiler product classes, as the products cannot reach the same water temperature as conventional boilers and cannot provide sufficient heating year-round without assistance. AHRI recommended DOE update the current definition of a "boiler" to include the ability to provide the required heat on the coldest day of the year. AHRI further recommended that given the difference in the form, fit, and function of heat pumps and conventional boilers, DOE should establish a separate definition and product class for these heat pump products. (AHRI, No. 40 at p. 3)

In contrast, Rheem, NYSERDA, the Joint Advocates, and NEEA all suggested that heat pump boilers are capable of meeting home heating design loads and should be considered as consumer boilers. (Rheem, No. 37 at p. 3; NYSERDA, No. 33 at p. 2; Joint Advocates, No. 35 at pp. 1-2; NEEA, No. 36 at pp. 1-2) Rheem also stated that while heat pumps may not reach the same maximum temperatures as conventional products, heat pumps can provide adequate space heating in many applications. (Rheem, No. 37 at p. 2)

In the March 2023 TP Final Rule, which was the most recent rulemaking amending the consumer boiler test procedure, DOE addressed similar comments suggesting hydronic air-to-water heat pump boilers and water-to-water heat pump boilers should be excluded from the "boiler" definitions because they cannot provide the same maximum water temperature as non-heat pump hydronic systems. Specifically, in the March 2023 TP Final Rule, DOE noted that neither the EPCA definition nor DOE's definitions at 10 CFR 430.2 for consumer boilers provide a minimum water temperature requirement and, thus, do not exclude hydronic heat pump boilers from being considered as consumer boilers. DOE also noted in the March 2023 TP Final Rule that hydronic heat pump boilers are marketed as providing the principal heating source for a residence. 88 FR 15510, 15515-15516 (March 13, 2023).

In response to the comments received on the May 2022 Preliminary Analysis, DOE again reviewed the market for hydronic heat pumps. Based on its review of the hydronic heat pumps currently on the market, DOE agrees with Rheem, NYSERDA, the Joint Advocates, and NEEA that hydronic heat pumps can provide enough space heating to serve home design loads in many applications. These products utilize only single-phase electric current or direct current in conjunction with natural gas, propane, or home heating oil, can be designed to be the principal heating source for the living space of a residence, are not contained within the same cabinet with a central air conditioner whose rated cooling capacity is above 65,000 Btu/h, meet the definition of an "electric boiler," and have a heat input rate of less than 300,000 Btu/h (*i.e.*, the requirement for electric boilers). As such, hydronic heat pumps which are designed to be the principal heating source of the living space of a residence meet the criteria of "furnace" as defined in EPCA at 42 U.S.C. 6291(23). Further, the Department notes that these products also meet DOE's codified regulatory definition for "low pressure steam or hot water boiler." Therefore, DOE considers hydronic heat pumps to be within the scope of coverage for consumer boilers. However, as discussed in section III.C of this document, there is no currently-applicable test procedure for hydronic heat pump consumer boilers, and as a result, DOE has not considered these products further in this NOPR.

In this NOPR, DOE has considered products which meet the definitions for "electric boiler" and "low pressure steam or hot water boiler" to be consumer boilers within the scope of this rulemaking, with the exception of hydronic heat pump boilers, for which there is currently no applicable test procedure to determine compliance with standards.

See section IV.A.1 of this document for discussion of the product classes analyzed in this NOPR.

C. Test Procedure

EPCA sets forth generally applicable criteria and procedures for DOE's adoption and amendment of test procedures. (42 U.S.C. 6293) Manufacturers of covered products must use these test procedures to quantify the efficiency of their product, to certify to DOE that their product complies with energy conservation standards, and when making efficiency-related representations to the public. (42 U.S.C. 6293(c) and 42 U.S.C. 6295(s)) EPCA states that the AFUE is the efficiency descriptor for furnaces and boilers (*See* 42 U.S.C. 6291(20) and (22)); however, as discussed in section II.A of this document, DOE is required to also account for standby mode and off mode energy consumption. Accordingly, for the current consumer boiler energy conservation standards, AFUE is the active mode efficiency metric, while $P_{W,SB}$ and $P_{W,OFF}$ are the metrics for standby mode and off mode electrical energy consumption, respectively (*see* 10 CFR 430.32(e)(2)(iii)). All three of these metrics are measured by the DOE test procedure for consumer boilers.

On March 13, 2023, DOE published a final rule in the *Federal Register* amending the test procedure for consumer boilers (March 2023 TP Final Rule). 88 FR 15510. The amended test procedure became effective on April 12, 2023.

Prior to April 12, 2023, the DOE test procedure for determining the AFUE, $P_{W,SB}$, and $P_{W,OFF}$ of consumer boilers was located at appendix N to subpart B of 10 CFR part 430 (appendix N) and referenced American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) Standard 103-1993, "Method of Testing for Annual Fuel Utilization Efficiency of Residential Central Furnaces and Boilers"[16] and International Electrotechnical Commission (IEC) 62301 (Edition 2.0), "Household electrical appliances—Measurement of standby power." AFUE is an annualized fuel efficiency metric that fully accounts for fuel consumption in active, standby, and off modes but does not include auxiliary electrical energy consumption. $P_{W,SB}$ and $P_{W,OFF}$ are measures of the standby mode and off mode power consumption, respectively, in watts.

In the March 2023 TP final rule, DOE updated appendix N to remove the provisions applicable only to consumer boilers and to rename the appendix "Uniform Test Method for Measuring the Energy Consumption of Furnaces." Correspondingly, the final rule established a new test procedure specific to consumer boilers in a new appendix EE to subpart B of 10 CFR part 430 (appendix EE). On and after September 11, 2023, manufacturers will be required to use the amended test procedure (though manufacturers may opt to do so early (*i.e.*, any time after April 12, 2023)), per the March 2023 TP Final Rule, to determine ratings for consumer boilers. The amended test procedure located at appendix EE consists of all provisions that were previously included in appendix N relevant to consumer boilers, with the following modifications:

[16] American Society for Testing and Materials (ASTM) Standard D2159-09 (Reapproved 2013), "Standard test methods and procedures for Smoke Density in Flue Gases From Burning Distillate Fuels," (ASTM D2156-09 (R2013)) is also referenced by the appendix EE test procedure for setting up oil-fired burners.

Incorporating by reference the current revision to the applicable industry standard, American National Standards Institute (ANSI)/ASHRAE Standard 103-2017, "Methods of Testing for Annual Fuel Utilization Efficiency of Residential Central Furnaces and Boilers;"

Incorporating by reference the current revision of American Society for Testing and Materials (ASTM) Standard D2156-09 (Reapproved 2018), "Standard Test Method for Smoke Density in Flue Gases from Burning Distillate Fuels;"

Incorporating by reference ANSI/ASHRAE Standard 41.6-2014, "Standard Method for Humidity Measurement;"

Updating the definitions to reflect the changes in ANSI/ASHRAE 103-2017 as compared to ANSI/ASHRAE 103-1993;

Removing the definition of "outdoor furnace or boiler" from 10 CFR 430.2;

Making certain corrections to improve the accuracy, repeatability, and reproducibility of calculations within the test procedure.

88 FR 15510, 15512-15513 (March 13, 2023).

DOE determined that the amendments in the March 2023 TP Final Rule would minimally impact the measured efficiency of certain consumer boilers, and retesting and re-rating would not be required. 88 FR 15510, 15514 (March 13, 2023). Therefore, DOE expects that the energy efficiency and energy consumption ratings currently achieved are still representative of ratings that would be achieved under the revised test method. As a result, DOE evaluated potential amended energy conservation standards for consumer boilers using current market data.

As discussed in section III.B of this document, DOE has become aware of hydronic air-to-water and water-to-water heat pumps, which DOE has determined meet the definitional criteria to be classified as consumer boilers. However, the AFUE metric described in ASHRAE 103-2017 (which is incorporated by reference into appendix EE) calculates the efficiency of an electric boiler as 100 percent minus jacket loss,[17] which provides a representative measure of efficiency for electric boilers using electric resistance technology, for which an efficiency value of 100 percent (the ratio of heat output to energy input) is the maximum upper limit that technically could be achieved. DOE concluded that the AFUE metric would not provide a representative or meaningful measure of efficiency for a boiler with a heat pump supplying the heat input, because heat pump efficiency (in terms of heat output to energy input) typically exceeds 100 percent, and the AFUE metric does not allow for ratings greater than 100 percent for electric boilers. 88 FR 15510, 15515 (March 13, 2023). Similarly, the ASHRAE 103-2017 test procedure assumes a maximum value of 100 percent for gas-fired and oil-fired boilers when calculating the steady-state efficiency and heating seasonal efficiency, such that the methodology would not result in representative AFUE values for gas-fired or oil-fired absorption heat pump boilers.

Rheem, NYSERDA, the Joint Advocates, and NEEA all urged DOE to develop a test procedure for heat pump consumer boilers. (Rheem, No. 37 at p. 3; NYSERDA, No. 33 at p. 2; Joint Advocates, No. 35 at p. 2; NEEA, No. 36 at p. 2)

[17] The term "jacket loss" is used by industry to mean the transfer of heat from the outer surface (*i.e.*, jacket) of a boiler to the ambient air surrounding the boiler.

DOE will consider heat pump boilers when re-evaluating the test procedure for consumer boilers in a future rulemaking. As noted in section III.B of this document, due to the lack of a Federal test procedure at this time which adequately addresses AFUE for heat pump boilers, DOE has initially determined not to analyze heat pump boilers in this standards rulemaking. However, the standby mode and off mode power consumption test procedures in appendix EE remain applicable to heat pump boilers; hence, these metrics are required for heat pump boilers. Similarly, the statutory design requirements at 10 CFR 430.32(e)(2)(iii)(A) apply to these products.

D. Boilers Not Requiring Electricity

On July 28, 2008, DOE published a final rule technical amendment in the *Federal Register* to codify the requirements that would be applicable to consumer boilers as established in the Energy Independence and Security Act of 2007. 73 FR 43611. That final rule codified, as per the statute, that a boiler that is manufactured to operate without any need for electricity or any electric connection, electric gauges, electric pumps, electric wires, or electric devices shall not be required to meet the current minimum AFUE standards or design requirements for consumer boilers. *Id.* at 73 FR 43613.

As a result of this statutory exception, the regulations require that boilers manufactured to operate without any need for electricity or any electric connection, electric gauges, electric pumps, electric wires, or electric devices must still meet the minimum AFUE requirements in 10 CFR 430.32(e)(2)(i)—namely, a minimum AFUE of 80 percent (for all classes except gas-fired steam boilers), and 75 percent for gas-fired steam boilers.

In subsequent final rules, including the January 2016 final rule, DOE maintained this exception for boilers not requiring electricity as required by EPCA; however, the codified language had a technical error wherein the exception inadvertently only applied to boilers manufactured on or after September 1, 2012, and before January 15, 2021 (see 10 CFR 430.32(e)(2)(v), which only references 10 CFR 430.32(e)(2)(ii)). The provisions at 10 CFR 430.32(e)(2)(v) apply also to boilers manufactured on or after January 15, 2021 (which must meet the requirements at 10 CFR 430.32(e)(2)(iii)).

In this NOPR, DOE proposes to make technical amendments to the standards for consumer boilers to clarify that the aforementioned exceptions continue to apply.

E. Technological Feasibility

1. General

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

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. Sections 6(b)(3)(ii)–(v) and 7(b)(2)–(5) of appendix A. Section IV.B of this document discusses the results of the screening analysis for consumer boilers, particularly the designs DOE considered, those it screened out, and those that are the basis for the potential standards considered in this rulemaking. For further details on the screening analysis for this rulemaking, see chapter 4 of the NOPR TSD.

2. Maximum Technologically Feasible Levels

When DOE proposes to adopt an amended standard for a type or class of covered product, it must determine the maximum improvement in energy efficiency or maximum reduction in energy use that is technologically feasible for such product. (42 U.S.C. 6295(p)(1)) Accordingly, in the engineering analysis, DOE determined the maximum technologically feasible ("max-tech") improvements in energy efficiency for consumer boilers, 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.1.b of this document and in chapter 5 of the NOPR TSD.

F. Energy Savings

1. Determination of Savings

For each TSL, DOE projected energy savings from application of the TSL to consumer boilers purchased in the 30-year period that begins in the year of compliance with the proposed standards (2030–2059).[18] The savings are measured over the entire lifetime of consumer boilers purchased in the previous 30-year period. DOE quantified the energy savings attributable to each TSL as the difference in energy consumption between each standards case and the no-new-standards case. The no-new-standards case represents a projection of energy consumption that reflects how the market for a product would likely evolve in the absence of new or amended energy conservation standards.

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

[18] Each TSL is composed of specific efficiency levels for each product class. The TSLs considered for this NOPR are described in section V.A of this document. DOE conducted a sensitivity analysis that considers impacts for products shipped in a 9-year period.

fuels), and, thus, presents a more complete picture of the impacts of energy conservation standards.[19] DOE's approach is based on the calculation of an FFC multiplier for each of the energy types used by covered products or equipment. For more information on FFC energy savings, see section IV.H.2 of this document.

2. Significance of Savings

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

The significance of energy savings offered by a new or amended energy conservation standard cannot be determined without knowledge of the specific circumstances surrounding a given rulemaking.[20] For example, some covered products and equipment have most of their energy consumption occur during periods of peak energy demand. The impacts of these products on the energy infrastructure can be more pronounced than products with relatively constant demand. Accordingly, DOE evaluates the significance of energy savings on a case-by-case basis, taking into account the significance of cumulative FFC national energy savings, the cumulative FFC emissions reductions, and the need to confront the global climate crisis, among other factors. DOE

[19] The FFC metric is discussed in DOE's statement of policy and notice of policy amendment. 76 FR 51281 (August 18, 2011), as amended at 77 FR 49701 (August 17, 2012).

[20]The numeric threshold for determining the significance of energy savings, established in a final rule published in the *Federal Register* on February 14, 2020 (85 FR 8626, 8670), was subsequently eliminated in a final rule published in the *Federal Register* on December 13, 2021 (86 FR 70892, 70906), which went into effect on January 12, 2022.

has initially determined the energy savings from the proposed standard levels are "significant" within the meaning of 42 U.S.C. 6295(o)(3)(B).

G. Economic Justification

1. Specific Criteria

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

a. Economic Impact on Manufacturers and Consumers

In determining the impacts of a potential amended standard on manufacturers, DOE conducts an MIA, as discussed in section IV.J of this document. DOE first uses an annual cash-flow approach to determine the quantitative impacts. This step includes both a short-term assessment—based on the cost and capital requirements during the period between when a regulation is issued and when entities must comply with the regulation—and a long-term assessment over a 30-year period. The industry-wide impacts analyzed include: (1) INPV, which values the industry on the basis of expected future cash flows, (2) cash flows by year, (3) changes in revenue and income, and (4) other measures of impact, as appropriate. Second, DOE analyzes and reports the impacts on different types of manufacturers, including impacts on small manufacturers. Third, DOE considers the impact of standards on domestic manufacturer employment and manufacturing capacity, as well as the potential for standards to result in plant closures and loss of capital investment. Finally, DOE takes into account cumulative impacts of various DOE regulations and other regulatory requirements on manufacturers.

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

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

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

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

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

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

c. Energy Savings

Although significant conservation of energy is a separate statutory requirement for adopting an energy conservation standard, EPCA requires DOE, in determining the economic justification of a standard, to consider the total projected energy savings that are expected to result directly from the standard. (42 U.S.C. 6295(o)(2)(B)(i)(III)) As discussed in section III.F.1 of this document, DOE uses the NIA spreadsheet models to project national energy savings.

d. Lessening of Utility or Performance of Products

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

e. Impact of Any Lessening of Competition

EPCA directs DOE to consider the impact of any lessening of competition, as determined in writing by the Attorney General, that is likely to result from a proposed standard. (42 U.S.C. 6295(o)(2)(B)(i)(V)) It also directs the Attorney General to determine the impact, if any, of any lessening of competition likely to result from a proposed standard and to transmit such determination to the Secretary within 60 days of the publication of a proposed rule, together with an analysis of the nature and extent of the impact. (42 U.S.C. 6295(o)(2)(B)(ii)) DOE will transmit a copy of this proposed rule to the Attorney General with a request that the Department of Justice (DOJ) provide its determination on this issue. DOE will publish and respond to the Attorney General's determination in the final rule. DOE invites comment from the public regarding the competitive impacts that are likely to result from this proposed rule. In addition, stakeholders may also provide comments separately to DOJ regarding these potential impacts. See the **ADDRESSES** section for information to send comments to DOJ.

f. Need for National Energy Conservation

DOE also considers the need for national energy and water conservation in determining whether a new or amended standard is economically justified. (42 U.S.C. 6295(o)(2)(B)(i)(VI)) The energy savings from the proposed 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 proposed standards are likely to result in environmental benefits in the form of reduced emissions of air pollutants and GHGs associated with energy production and use. DOE conducts an emissions analysis to estimate how potential standards may affect these emissions, as discussed in section IV.K of this document; the estimated emissions impacts are reported in section V.B.6 of this document. DOE also estimates the economic value of emissions reductions resulting from the considered TSLs, as discussed in section IV.L of this document.

g. Other Factors

In determining whether an energy conservation standard is economically justified, DOE may consider any other factors that the Secretary deems to be relevant. (42 U.S.C. 6295(o)(2)(B)(i)(VII)) To the extent DOE identifies any relevant information regarding economic justification that does not fit into the other categories described previously, DOE could consider such information under "other factors."

2. Rebuttable Presumption

As set forth in 42 U.S.C. 6295(o)(2)(B)(iii), EPCA creates a rebuttable presumption that an energy conservation standard is economically justified if the additional cost to the consumer of a product that meets the standard is less than three times the value of the first year's energy savings resulting from the standard, as calculated under the applicable DOE test procedure. DOE's LCC and PBP analyses generate values used to calculate the effects that proposed energy conservation standards would have on the payback period for consumers. These analyses include, but are not limited to, the 3-year payback period contemplated under the rebuttable-presumption test. In addition, DOE routinely conducts an economic analysis that considers the full range of impacts to consumers, manufacturers, the Nation, and the environment, as required under

42 U.S.C. 6295(o)(2)(B)(i). The results of this analysis serve as the basis for DOE's evaluation of the economic justification for a potential standard level (thereby supporting or rebutting the results of any preliminary determination of economic justification). The rebuttable presumption payback calculation is discussed in section IV.F.9 and results reported in section V.B.1.c of this document.

IV. Methodology and Discussion of Related Comments

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

DOE used several analytical tools to estimate the impact of the standards proposed in this document. The first tool is a spreadsheet that calculates the LCC savings and PBP of potential amended or new energy conservation standards. The national impacts analysis uses a second spreadsheet set that provides shipments projections and calculates national energy savings and net present value of total consumer costs and savings expected to result from potential energy conservation standards. DOE uses the third spreadsheet tool, the Government Regulatory Impact Model (GRIM), to assess manufacturer impacts of potential standards. These three spreadsheet tools are available on the DOE website for this proposed rulemaking: *www1.eere.energy.gov/buildings/appliance_standards/standards.aspx?productid=45&action=viewcurrent*. Additionally, DOE used output from the latest version of the Energy Information Administration's (EIA's) *Annual Energy Outlook* (*AEO*), a widely known energy projection for the United States, for the emissions and utility impact analyses.

A. Market and Technology Assessment

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

1. Product Classes

When evaluating and establishing energy conservation standards, DOE may establish separate standards for a group of covered products (*i.e.*, establish a separate product class) if DOE determines that separate standards are justified based on the type of energy used, or if DOE determines that a product's capacity or other performance-related feature justifies a different standard. (42 U.S.C. 6295(q)) In making a determination whether a performance-related feature justifies a different standard, DOE must consider such factors as the utility of the feature to the consumer and other factors DOE determines are appropriate. (*Id.*)

The current product classes are divided by the type of energy used (*i.e.*, gas, oil, or electricity) and by the heat transfer medium (*i.e.*, steam or hot water) as shown in Table IV.1. (*See* 10 CFR 430.32(e)(2)) The current product classes were originally established by EISA 2007 and are codified at 10 CFR 430.32(e)(2)(iii)(A).

Table IV.1 Consumer Boiler Product Classes

Fuel Type	Heat Transfer Medium
Gas	Steam
	Hot Water
Oil	Steam
	Hot Water
Electric	Steam
	Hot Water

In the May 2022 Preliminary Analysis, DOE maintained these product classes, and the Department solicited feedback on whether any additional product classes would be necessary for consumer boilers, including a potential consideration for hydronic heat pump boilers. (*See* the Executive Summary of the preliminary analysis TSD). Multiple stakeholders provided feedback on potential additional product classes for fossil fuel-fired hot water boilers and hydronic heat pump boilers, as discussed in the subsections that follow.

a. Fossil Fuel-fired Hot Water Boilers[21]

On December 29, 2021, DOE published in the *Federal Register* a final interpretive rule for consumer furnaces, commercial water heaters, and similarly situated products or equipment (the December 2021 Interpretive Rule), which explained DOE's

[21] As discussed in chapter 3 of the NOPR TSD, due to the high temperature of steam, condensing operation is not utilized in steam boilers, and all steam boilers on the market are non-condensing. Therefore, the discussion in this section is only applicable to hot water boilers.

return to its historic position that, among other things, non-condensing technology and associated venting of the flue gases is not a performance-related "feature" that provides a distinct consumer utility under EPCA.[22] 86 FR 73947.

In the May 2022 Preliminary Analysis, DOE addressed several comments on the March 2021 RFI from stakeholders requesting that the Department consider non-condensing technology and associated venting to be a performance-related feature, (see chapter 2 of the preliminary TSD), and DOE maintained its position that non-condensing technology does not constitute a performance-related "feature," consistent with the December 2021 Interpretive Rule. 87 FR 26304, 26308 (May 4, 2022). In response to the May 2022 Preliminary Analysis, commenters provided follow-up feedback with more information regarding how condensing versus non-condensing technology would affect the applicable venting categories.

As discussed in chapter 3 of the NOPR TSD, manufacturers generally provide specific venting instructions based on the characteristics of the heating appliance. The National Fire Protection Association (NFPA) and ANSI maintain NFPA 54/ANSI Z223.1, "National Fuel Gas Code," which assigns four venting categories to gas-fired appliances. Category I venting is for nonpositive vent static pressures[23] and limited flue gas condensate[24] production in the vent; Category II venting is for nonpositive vent static pressures and excessive condensate production in the vent; Category III venting is for positive vent static pressures and limited condensate production in the vent, and Category

[22] For more information, see *www.regulations.gov/docket/EERE-2018-BT-STD-0018* (Last accessed Jan. 3, 2023).
[23] Static pressure is the pressure created by a fluid at rest relative to the measurement instrument. Here non-positive static pressure refers to the flue gases having a pressure lower than atmospheric pressure so no assistance is needed for the flue gases to escape through the vent system.
[24] Condensate refers to the moisture that condenses inside venting systems when the flue gas is cooled to below the dew point and liquid begins to condense on the walls of the vent system.

IV venting is for positive vent static pressures and excessive condensate production in the vent. Non-condensing boilers can use Category I venting, which is compatible with natural draft vent systems that use chimney venting, but condensing boilers require category IV venting, which is not compatible with natural draft vent systems. (Category II venting is not common for consumer boilers, and Category III venting can be used for non-condensing boilers but is also not compatible with natural draft vent systems.)

Crown and U.S. Boiler stated that the ability to vent residential boilers using Category I venting is a feature that must be preserved due to boilers being a primarily replacement market in older urban areas with limited exterior wall space suitable for a vent terminal, and they recommended that there should be a product class for Category I boilers. Crown stated that the elimination of Category I venting would result in the need for extensive renovations to some existing structures if the chimney can no longer be used, the potential for boilers to be used long after they are a safe option, the potential use of less safe heating equipment such as electric space heaters, or the possibility of poor venting reconfigurations that could lead to safety issues. Crown and U.S. Boiler stated that these ramifications cannot be addressed in the standards cost-benefit analysis. Crown and U.S. Boiler pointed to the preliminary TSD, which discussed that both the United Kingdom and European Union have exceptions to their condensing boiler standards that allow for installation of non-condensing boilers in difficult installation circumstances. (Crown, No. 30 at pp. 2–3; U.S. Boiler, No. 31 at p. 2)

WMT stated that it believes that EPCA (42 U.S.C. 6295(o)(4)) prohibits the elimination of non-condensing hot water boilers, and non-condensing operation constitutes a product feature per EPCA that warrants a separate product class under 42

U.S.C. 6295(q)(1), as stated by DOE in the January 2021 Interpretative Rule (86 FR 4776). (WMT, No. 32 at pp. 1–2) WMT suggested that non-condensing boilers in Category I venting should be a separate product class in order to recognize that these products operate at 180 °F return water temperatures, vent through Category I venting, and may be installed in insufficiently-insulated homes. WMT asserted that these homes also do not have the ability to increase heat emitter surface area, and, thus, the various efficiency levels analyzed in the preliminary analysis could not be achieved by this hypothetical new product class. (WMT, No. 32 at p. 7)

PB Heat advocated for a separate product class for non-condensing boilers, claiming that this action would secure cost-effective products for consumers, in terms of product lifespan and maintenance, as well as maintaining the consumer boiler replacement market. (PB Heat, No. 34 at p. 2)

In contrast, NYSERDA stated that condensing and non-condensing boilers should remain in the same product class because condensing operation is not a performance-related feature. NYSERDA indicated that challenging installations represent a small proportion of the market. NYSERDA provided data showing that almost 40 percent of all furnaces and boilers in New York achieve a condensing level of performance,[25] and commented that DOE's estimate that fewer than 5 percent of installations could be labeled as challenging is well-supported and reflective of the significant gain of market share that condensing products have achieved over the last twenty years. (NYSERDA, No. 33 at p. 3)

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[25] NYSERDA provided information from its 2019 Residential Building Stock Assessment, found online at *www.nyserda.ny.gov/About/Publications/Building-Stock-and-Potential-Studies/Residential-Building-Stock-Assessment* (Last accessed Jan. 3, 2023).

The Joint Advocates likewise supported DOE's decision to evaluate condensing and non-condensing boilers within a single product class (as discussed in chapter 2 of the preliminary TSD). The Joint Advocates stated that condensing technology provides the same utility, uses the same fuel source, and does not constitute a "performance related feature" that would warrant a separate product class from non-condensing technology. (Joint Advocates, No. 35 at p. 1) NEEA also supported DOE's decision to evaluate condensing and non-condensing boilers within a single product class, as both products utilize the same primary fuel source, neither provides unique consumer utility, and keeping them in the same class prevents non-condensing boiler manufacturers from obtaining a competitive, regulatory advantage over condensing boiler manufacturers (*i.e.*, by having less-stringent requirements). (NEEA, No. 36 at p. 1)

With respect to commenters' statements that non-condensing technology and associated venting is a "feature" that DOE's standards cannot make unavailable, DOE concluded in the December 2021 final interpretive rule that incorporation of non-condensing technology and associated venting is not a performance-related "feature" for the purpose of the EPCA prohibition at 42 U.S.C. 6295(o)(4). 86 FR 73955 73947, 73955 (Dec. 29. 2021). In support of that conclusion, DOE explained that given EPCA's focus on an appliance's major function(s), it is reasonable to assume that the consumer would be aware of performance-related features and would recognize such features as providing additional benefit in the appliance's performance of such major function. *Id.* For example, some boilers have Wi-Fi connectivity features that allow the consumer to remotely monitor and control their boiler.[26] In contrast to these features, an aspect of the appliance that does not provide any additional benefit to the consumer during operation would not be a performance-related feature that Congress would expect DOE to preserve at the expense of energy savings. With respect to boilers, some examples are heat exchanger designs or materials, burner designs, and ignition system designs. While all of these components are necessary parts of a boiler, they are not performance-related features that provide other additional benefit to the consumer during operation. Non-condensing technology and associated venting falls squarely into this category. Further, energy conservation standards work by removing the less-efficient technologies and designs from the market. For example, DOE set standards for furnace fans in 2014 that effectively eliminated permanent split capacitor motors from several product classes in favor of brushless permanent magnet motors, which are more efficient. 79 FR 38130. As a second example, the amended standards for residential clothes washers established by the May 31, 2012, rule effectively eliminated the use of electromechanical-style user interface controls from the market, in favor of fully electronic user interface controls—which enable more efficient energy and water performance. 77 FR 32307. As a third example, DOE published a final rule on June 17, 2013, adopting energy conservation standards for microwave oven standby mode and off mode. These standards effectively eliminated the use of linear power supplies from microwave oven control boards, in favor of switch-mode power supplies, which exhibit significantly lower standby mode and off mode power consumption. 78 FR 36316. It would completely frustrate the energy-

[26] For example, see: *https://www.viessmann-us.com/content/dam/public-brands/us/flyers/Vitodens_200_W_B2HE_06_2021.pdf/_jcr_content/renditions/original./Vitodens_200_W_B2HE_06_2021.pdf and https://ntiboilers.com/wp-content/uploads/2020/09/FTVN_Series-Handout_2020_Web.pdf.*

savings purposes of EPCA if DOE were to adopt an overly-broad reading of "features" that preserves less-efficient technologies without determining that boilers using those less-efficient technologies offer consumers an additional benefit during normal operation that other boilers do not offer.

For these reasons, DOE disagrees with commenters that eliminating non-condensing boiler technology and associated 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 boilers. Moreover, such a finding would preserve a less efficient technology with no unique consumer utility at the expense of a significant savings of energy and consumer benefit. Accordingly, for the purpose of the analysis conducted for this rulemaking, DOE did not analyze separate equipment classes for non-condensing and condensing boilers in this final rule.

In addition, while DOE agrees with NYSERDA that the number of challenging installations represent a decreasing proportion of the market because newer constructions can be designed around Category IV venting considerations, DOE also agrees with manufacturers that those few consumers with challenging installations could incur significant costs. But DOE does not agree with the assertion by Crown and U.S. Boiler that non-condensing technology and associated venting must be preserved because the costs of these challenging installations cannot be accounted for in DOE's economic analysis. First, as stated previously, non-condensing technology and associated venting is not a performance-related feature because, among other things, it does not provide additional benefit in the appliance's performance of its major function. Using existing venting can reduce installation costs, but that does not provide the consumer with any additional benefits during operation of the boiler. 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. 6295(o)(2)(B)(i)(II)) As a result, there is a clear distinction in EPCA between the purposes of the product class provision in 42 U.S.C. 6295(q)—preserve performance-related features in the market—and the economic justification requirement in 42 U.S.C. 6295(o)(2)(B)—determine whether the benefits, *e.g*., reduced fuel costs for an appliance, of a proposed standard exceed the burdens, *e.g*., increased installation cost. And, DOE has accounted for the costs of altering or replacing an existing venting system with a venting system that will accommodate a condensing furnace as part of the installation costs in the LCC analysis (see section IV.F.2 of this document and chapter 8 of the NOPR TSD).

With respect to Crown and U.S. Boiler's concerns regarding safety issues caused by condensing boilers, DOE is not aware of, nor have the commenters provided, any data showing that non-condensing boilers are a safer option than condensing boilers. DOE notes that condensing boilers are currently widely available on the market and have been available for decades, and in certain locations have experienced widespread adoption (even having achieved greater market share than non-condensing boilers in some areas). Given the track record of condensing boilers being installed and operated safely, DOE finds that installers are capable of safely installing and venting condensing boilers, even in circumstances that would require the venting system to be upgraded.

Additionally, in response to WMT, DOE expects that condensing boilers and non-condensing boilers alike would be capable of operating with return water temperatures of

180 °F. Thus, the return water temperature provided by the product would not be reason to differentiate product classes. DOE understands that condensing boilers, when operating at these temperatures, would have minimal condensation occurring in the heat exchanger, which does result in non-condensing efficiency. This effect is accounted for in the energy use analysis (*see* section IV.E of this document).

b. Hydronic Heat Pump Boilers

In the May 2022 Preliminary Analysis, DOE specifically sought information regarding whether there are any performance-related features of heat pump boilers which would justify a separate product class. DOE also requested information on the expected market for such products (*see* the Executive Summary of the preliminary analysis TSD).

Rheem suggested that DOE should include heat pump boilers in the existing product class structure, but if that cannot be accomplished, a separate product class may be warranted, with changes to the regulatory definition for consumer boilers. (Rheem, No. 37 at p. 2)

Crown and U.S. Boiler stated that heat pump boilers are unable to generate water temperatures high enough to satisfy the design heating load of the vast majority of the residential hot water heating systems in the United States, and, therefore, if heat pump boilers are considered to be consumer boilers, they should be placed in their own products class. (Crown, No. 30 at p. 3; U.S. Boiler, No. 31 at p. 3) BWC commented that heat pump boilers are not able to provide the same utility as conventional consumer boilers, especially during extreme environmental conditions, and, therefore, should be placed in a separate class than conventional consumer boilers. (BWC, No. 39 at p. 1)

As discussed in section III.C of this document, the DOE test procedure for consumer boilers would not currently provide test results that are representative of the energy use or energy efficiency of an air-to-water or water-to-water heat pump boiler, and without an appropriate test procedure for these products at this time, DOE did not analyze heat pump boilers in this NOPR.

2. Market Assessment

In the market assessment, DOE obtains information on the present and past industry structure and market characteristics in order to inform multiple other analyses. In preparing the May 2022 Preliminary Analysis, DOE reviewed available public literature to develop an understanding of the consumer boiler industry in the United States, including assessing manufacturer market share and characteristics, existing regulatory and non-regulatory initiatives for improving product efficiency, and trends in product characteristics and retail markets. The Department used data sources such as its own Compliance Certification Database (CCD)[27], supplemented by information in California Energy Commission's Modernized Appliance Efficiency Database System (MAEDbS),[28] AHRI's Directory of Certified Product Performance,[29] and the U.S. Environmental Protection Agency's ENERGY STAR product finder.[30] DOE specifically sought comment in the May 2022 Preliminary Analysis on whether manufacturer model counts from publicly-available databases accurately reflect manufacturer market shares

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[27] DOE's CCD can be found online at: *www.regulations.doe.gov/certification-data/#q=Product_Group_s%3A** (Last accessed Jan. 3, 2023).
[28] MAEDbS can be found online at: *cacertappliances.energy.ca.gov/Pages/ApplianceSearch.aspx* (Last accessed Jan. 3, 2023).
[29] AHRI's Directory of Certified Product Performance can be found online at: *www.ahridirectory.org/Search/SearchHome?ReturnUrl=%2f* (Last accessed March 1, 2023).
[30] EPA's ENERGY STAR product finder can be found online at: *www.energystar.gov/products/products_list* (Last accessed Jan. 3, 2023).

on a model-weighted or sales-weighted basis in order to inform the LCC analysis by providing insights into the typical consumer or installation scenarios (*see* the Executive Summary of the consumer boilers preliminary TSD).

WMT stated that certification databases do not indicate shipments and, thus, reflect the distribution of neither input capacities nor efficiencies. (WMT, No. 32 at pp. 7–8) WMT commented that the boilers market is increasingly transitioning towards higher efficiencies, and this is occurring in specific areas and regions where higher-efficiency consumer boilers have the most financial benefit and the application allows for it. The commenter stated that areas with lower adoption rates are based less on need for financial benefit than the inability to adapt the building to lower water circulation temperatures required for high-efficiency products; in other words, regions where local building codes or policies result in increased installation costs or even prohibit condensing appliance installations have the least transition towards higher efficiencies. WMT commented that this would disproportionally affect certain consumer subgroups. (WMT, No. 32 at p. 11)

Similarly, Rheem did not recommend using model counts from publicly-available databases to reflect market shares. (Rheem, No. 37 at p. 2)

AHRI also disagreed with the Department's use of manufacturer model counts from publicly-available databases to reflect manufacturer market shares on a model-weighted or sales-weighted basis, claiming that these databases do not accurately represent market share and misrepresent the market. (AHRI, No. 40 at p. 3) In a follow-up submission, AHRI provided information to DOE containing a market share analysis for gas-fired hot water boilers. AHRI stated that its contractor survey, completed in July

2022, was conducted in conjunction with the Air Conditioning Contractors of America (ACCA) and the Plumbing, Heating, and Cooling Contractors Association (PHCC), and that it gathered feedback from over 140 experienced contractors. (AHRI, No. 42 at p. 1)

DOE notes that the data provided by AHRI contained insights into manufacturer shipments, installation types, consumer boiler lifetimes, and other parameters which DOE has incorporated, as applicable, into its market assessment and considered for the downstream analyses (*e.g.*, LCC and PBP, shipments).

3. Technology Options

In the preliminary market analysis and technology assessment, DOE identified 13 technology options that would be expected to improve the efficiency (in terms of the three regulated metrics: AFUE, $P_{W,SB}$, and $P_{W,OFF}$) of consumer boilers, as measured by the DOE test procedure:

Technology options to improve AFUE: heat exchanger improvements, modulating operation, vent dampers, direct vent, pulse combustion, premix burners, burner derating, low-pressure air-atomized oil burners, delayed-action oil pump solenoid valves, and electronic ignition.

Technology option to improve $P_{W,SB}$ and $P_{W,OFF}$: control relays for models with brushless permanent magnet (BPM) motors, transformer improvements, and switching mode power supplies.

Additionally, based on an extensive review of publicly available literature, DOE listed technologies that could potentially improve the overall efficiency of consumer boilers but would not result in improvements to AFUE, $P_{W,SB}$, or $P_{W,OFF}$. These were, namely: micro combined heat and power systems, improved motor efficiency, positive shut-off valves for oil burner nozzles, renewable natural gas[31], and heat pump technology. See chapter 3 of the preliminary TSD for details. After developing the preliminary list of technology options, DOE requested feedback on this list. The Department also sought information regarding the adoption of low-loss transformers and switching mode power supplies in consumer boilers to meet the existing $P_{W,SB}$ and $P_{W,OFF}$ standards.

BWC disagreed with some of the design characteristics which were presented in Table 3.3.2 of the preliminary TSD, stating that non-condensing copper heat exchangers can be either Category I or II venting, not just Category II venting. BWC also stated that condensing operation can begin in venting at around the 85-percent AFUE level, as opposed to the 88-percent AFUE threshold described in the preliminary TSD. BWC recommended that DOE perform a more up-to-date teardown analysis to address these discrepancies. (BWC, No. 39 at p. 2) In response, DOE believes that BWC may have misinterpreted the information provided in this table. Table 3.3.2 of the preliminary TSD simply provides brief descriptions of the terms that are used to characterize consumer boiler designs, and these terms are grouped together in accordance with the corresponding design parameter. DOE stated in Table 3.3.2 that copper heat exchangers are used in some non-condensing models, not that these heat exchangers are limited to Category II venting.

Rheem stated that renewable natural gas likely has little effect on efficiency compared to traditional natural gas, and, therefore, the commenter recommended that this

[31] Renewable natural gas is methane (natural gas) that is produced via the breakdown of biological material, then treated to remove contaminants.

technology option should be removed from the analysis. (Rheem, No. 37 at p. 2) DOE agrees that renewable natural gas would not result in improvements to AFUE, $P_{W,SB}$, or $P_{W,OFF}$, and, thus, this fuel has not been considered as a technology option in this NOPR.

AHRI stated that it does not have data on any current technologies that can be used to reach a more-stringent standard, but further stated that consumer boilers are typically installed within the thermal envelope of the building and any energy lost from the consumer boiler results in useful heat provided to the building. (AHRI, No. 40 at pp. 3–4) In response, DOE notes that a consumer boiler's primary purpose is to deliver heat to the hot water or steam in the home heating loop. DOE understands the comment from AHRI to mean that any technologies which limit the loss of heat from the consumer boiler to its immediate surroundings (*i.e.*, heat that does not go into the hot water or steam) should not be considered as improving the efficiency of the consumer boiler because the heat is ultimately delivered to the building even if it is not through the hot water or steam. The previous appendix N test procedure and the new appendix EE test procedure both account for this by assigning a value of 0 to the jacket loss factor (a value which quantifies heat lost directly to the consumer boiler's surroundings through its jacket) if the boiler is non-weatherized, as it is assumed to be located within the conditioned space of the building.[32] At the time of this analysis, DOE did not identify any commercially available weatherized consumer boilers. The technology options identified as improving AFUE are consistent with this understanding.

[32] In defining the AFUE metric, EPCA states that this descriptor is based on the assumption that all weatherized warm air furnaces or boilers are located out-of-doors, and boilers which are not weatherized are located within the heated space. (42 U.S.C. 6291(20)(A)-(C)) The jacket loss is, therefore, assigned a value of 0 for any boilers that are non-weatherized.

DOE requests information on the market share of weatherized consumer boilers and the typical jacket losses of such products.

BWC strongly discouraged DOE from evaluating more-stringent standby mode and off mode power consumption ($P_{W,SB}$ and $P_{W,OFF}$) standards. BWC commented that, based on its own testing, it has not seen a significant decrease in energy used in standby mode through the use of larger, low-loss transformers. BWC also stated that DOE's methodology of examining a few discrete components and their energy consumption instead of the overall power consumption of the consumer boiler was of concern to BWC because it fails to account for the power consumed by a consumer boiler's entire electrical system (including all ancillary components), and it recommended not to pursue more-stringent power consumption standards. (BWC, No. 39 at p. 2)

In response, DOE has considered this information about the implementation of low-loss transformers and has tentatively determined that it remains uncertain whether this technology option can be used to further reduce standby mode and off mode energy consumption. In the January 2016 Final Rule, DOE had determined that low-loss transformers and switching mode power supplies would be necessary to achieve the $P_{W,SB}$ and $P_{W,OFF}$ standards that were promulgated in that rule (which were set at the maximum technologically feasible levels at the time). 81 FR 2320, 2407-2408 (Jan. 15, 2016). As discussed in chapter 5 of the NOPR TSD, transformer improvements (*i.e.*, low loss transformers) and switching mode power supplies would have uncertain potential to further improve standby mode and off mode power consumption because these were considered to be the maximum technologically feasible designs in the January 2016 Final Rule which established the current standards. Thus, low-loss transformers and switching mode power supplies were not considered as potential design options for consumer boilers in this NOPR. In this NOPR, DOE tentatively determined that control relays are the only viable technology option remaining which can lead to discernible improvements to $P_{W,SB}$ and $P_{W,OFF}$. However, as discussed in section IV.B of this document, control relays were screened out from further consideration, leaving no design options currently identified to improve these metrics. As a result, this NOPR did not further assess potential amended $P_{W,SB}$ and $P_{W,OFF}$ standards, and only amended AFUE standards are proposed. See chapters 3 and 4 of the NOPR TSD for further details of the technology assessment leading to this tentative conclusion not to further analyze amended standby mode and off mode energy consumption standards at this time.

DOE received multiple comments in response to the May 2022 Preliminary Analysis regarding heat pumps as technology options for consumer boilers. NYSERDA, the Joint Advocates, and NEEA recommended that heat pumps be considered as technology options once a test procedure for these products is established, suggesting that heat pump boilers would define the maximum technologically feasible efficiency for consumer boilers. (NYSERDA, No. 33 at p. 2; Joint Advocates, No. 35 at pp. 1–2; NEEA, No. 36 at pp. 1–2)

Additionally, NYSERDA stated that New York's ambitious climate objectives will require retrofitting the heating systems of existing homes to reduce GHGs, and given the prevalence of hydronic systems in the New York market, providing consumers choices for low-emission hydronic heating solutions will be important. (NYSERDA, No. 33 at p. 2)

The Joint Advocates commented that hydronic heating is used in 8 percent of homes overall in the United States, including 28 percent of homes in the Northeastern region, and heat pump boilers will assist that proportion's rise to higher efficiencies as State policies shift forward. The Joint Advocates stated that gas absorption heat pumps can replace standard gas space heating appliances in cold climates, operating at much higher theoretical AFUE values. (Joint Advocates, No. 35 at pp. 1–2)

NEEA recommended that DOE should evaluate electric and gas heat pump technology, as well as dual-fuel heat pump boilers and gas absorption heat pump boilers, for consumer boilers as potential "max-tech" efficiency levels. NEEA stated that these products provide the same product utility as conventional consumer boilers and that these products are commercially available. (NEEA, No. 36 at pp. 1–2)

WMT, on the other hand, stated that it is not aware of viable heat pump boilers in the market which can operate consistently and reliably at circulating water temperatures sufficient for heating needs across the Nation. (WMT, No. 32 at p. 8) AHRI commented that it did not have data regarding current technologies that can be used to meet more-stringent standards or the adoption of electric heat pump or gas heat pump technology in the consumer boiler market. (AHRI, No. 40 at pp. 3–4)

As discussed in section IV.A.1.b of this document, DOE has tentatively determined that heat pump technology would not yield improvements in AFUE per the new appendix EE test procedure, and that further development of the test procedure would be necessary in order to address these novel products. Therefore, DOE has not included heat pump technologies in its list of technology options for this NOPR. The

Department appreciates the feedback and information provided by stakeholders on this topic and will continue to evaluate heat pump boilers in a future rulemaking.

B. Screening Analysis

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

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

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

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

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

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

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

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

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

In response to the May 2022 Preliminary Analysis, several commenters raised concerns regarding the consideration of an 85-percent AFUE efficiency level for gas-fired hot water boilers, stating that this particular efficiency could have issues with installation and repair, reliability, and safety. These commenters assert that this issue should have bearing on DOE's consideration of technology options for this rulemaking.

AGA, APGA, and NPGA stated that if DOE were to propose 85-percent AFUE as a standard, it would be too close to condensing operation to be safely implemented with existing Category I venting systems, and that forcing the consumer to upgrade to condensing technology would place undue burden and expense on the consumer. AGA, APGA, and NPGA stated that manufacturers would not produce consumer boilers that are prone to failure, instead opting to make condensing boilers, thereby limiting the choice of and increasing the burden on the consumer. (AGA, APGA and NPGA, No. 38 at p. 3) Rheem similarly expressed concern that the 85-percent efficiency level is too close to condensing operation to be used safely without reliability issues and costly upgrades. (Rheem, No. 37 at p. 4)

Reiterating its comments from the previous standards rulemaking, Crown provided data from the U.S. Consumer Product Safety Commission (CPSC) on failure modes that led or contributed to carbon monoxide incidents associated with modern furnaces and boilers between the years 2002–2009 and concluded that, as the AFUE increases, the likelihood that one of these failure modes would cause a carbon monoxide incident also increases. Crown stated that this is due the flue gases being less buoyant at higher efficiencies, and, thus, being less able to overcome the effects of depressurization, partial blockage, back-drafting, or an improperly designed vent system; additionally, cooler flue gases are more likely to cause damage to the vent system if something else also goes wrong (*e.g.*, Crown provided the example of trace halogen aspiration into the consumer boiler). (Crown, No. 30 at pp. 3–5) U.S. Boiler provided the same comments as Crown. (U.S. Boiler, No. 31 at pp. 3–5)

Crown stated that setting a standard for gas-fired hot water boilers at 85-percent AFUE would completely ignore the safety and reliability concerns that can result from the installation of a consumer boiler operating at this efficiency level into a Category I chimney. Crown provided graphical data charting flue gas CO_2 concentration and net flue gas temperature that suggested that the steady-state efficiency at which a consumer boiler could operate while maintaining a Category I designation would be between 82.7–84.1-percent AFUE. Crown made the observation that, since AFUE will never exceed steady-state efficiency, the current standard at 84-percent AFUE, for all practical purposes, is already at this limit. Crown argued that while there are consumer boilers on the market at 85-percent AFUE, not all of them are certified to ANSI Z21.13, "Gas-Fired Low Pressure Steam And Hot Water Boilers," and are, therefore, not officially Category I venting. Crown also stated that these 85-percent AFUE consumer boilers have modifications such as power gas burners and operate in conditions different than laboratory conditions where AFUE was determined, creating uncertainty on whether they would be safe in all field conditions. Crown commented that while there are explicit instructions on how to install consumer boilers, manufacturers have little control on whether these instructions are followed, and an AFUE minimum of 85 percent introduces more of a safety risk to the consumer; therefore, a standard at this level would force all manufacturers to either prescribe vent requirements more stringent than those currently in the National Fuel Gas Code and/or give up any remaining extra safety margin they have built into their products for suboptimal vent systems, all for an incremental energy savings benefit likely amounting to a rounding error. (Crown, No. 30 at pp. 3–5) U.S. Boiler provided the same comments. (U.S. Boiler, No. 31 at pp. 3–5)

In response, DOE understands that Crown, U.S. Boiler, APA, APGA, and NPGA are concerned about the safety of installing gas-fired hot water boilers with incremental heat exchanger improvements (leading to an AFUE of 85 percent) within current Category I venting systems. However, as a technology option, an increase in heat exchanger effectiveness alone does not pose a safety risk for consumers or service technicians. To this point, in the January 2016 Final Rule, the Department recognized that certain efficiency levels could pose health or safety concerns under certain conditions if they are not installed properly in accordance with manufacturer specifications. However, these concerns can be resolved with proper product installations and venting system design; this is evidenced by the significant shipments of products that are currently commercially available at these efficiency levels, as well as the lack of restrictions on the installation location of these units in installation manuals. In addition, DOE noted that products achieving these efficiency levels have been on the market since at least 2002, which demonstrates their reliability, safety, and consumer acceptance. In some circumstances, if the potential for condensate is high, different vent materials (such as a high grade stainless steel vent) may be required to withstand the condensate. High efficiency condensing boilers typically use PVC/CPVC venting since the exhaust gases are cool enough. Given the significant product availability and the amount of time products at these efficiency levels have been available on the market, DOE continues to believe that products at these efficiency levels are safe and reliable when installed correctly. 81 FR 2320, 2344-2345 (Jan. 15, 2016).

Further, DOE examined the most recent report from the CPSC regarding carbon monoxide incidents related to the use of consumer products, which presented data from 2018 (CPSC 2018 Report).[33] This report discusses that information collected on the carbon monoxide incidents often describes conditions of compromised vent systems, flue passageways, and chimneys for furnaces, boilers, and other heating systems. CPSC 2018 Report at p. 9. Specifically, the CPSC 2018 Report states that "[a]ccording to the

[33]M.V. Hnatov, "Non-Fire Carbon Monoxide Deaths Associated with the Use of Consumer Products; 2018 Annual Estimates," U.S. Consumer Product Safety Commission, September 2021. Available online at *www.cpsc.gov/s3fs-public/Non-Fire-Carbon-Monoxide-Deaths-Associated-with-the-Use-of-Consumer-Products-2018-Annual-Estimates.pdf?VersionId=IN1CTo8Njoxta0CmddOUl2t.tmQ.iEEb* (Last accessed Jan. 3, 2023).

information available, some products had vents that became detached or were installed/maintained improperly. Vents were also sometimes blocked by soot caused by inefficient combustion, which, in turn, may have been caused by several factors, such as leaky or clogged burners, an over-firing condition, or inadequate combustion air. Other furnace-related conditions included compromised heat exchangers or filter doors/covers that were removed or not sealed. Some products were old and apparently not well maintained. Other incidents mentioned a backdraft condition, large amounts of debris in the chimney, and the use of a product that was later prohibited by the utility company and designated not to be turned on until repaired." *Id*. Based on this information, DOE has tentatively determined that it is the potential for older or improperly maintained venting and burner systems to be inadequate which may pose a safety risk, and not the higher-efficiency consumer boiler itself. In other words, high efficiency boilers available on the market today are just as safe as baseline boilers when they are installed and maintained properly. If either high-efficiency or low-efficiency boilers are not installed and maintained properly, then some potential for safety concerns may exist as outlined by the CPSC report. But DOE has not found, nor have commenters presented, evidence that more stringent standards for boilers would result in a reduction of boiler safety. In the LCC analysis, DOE accounts for the costs associated with correctly installing boilers (including modifications to vent system when appropriate), as well as preventative maintenance and any necessary repairs over the lifetime of a product. As a result, DOE has not screened out heat exchanger improvements as a technology option from this NOPR analysis.

PB Heat stated that the current minimum efficiency levels are close to the condensing range, and increasing them any further will reduce applications where Category I consumer boilers can be installed and, therefore, reduce consumer utility and access to affordable heating. (PB Heating, No. 34 at p. 1)

As stated in section IV.A.1.a of this document, in this rulemaking, DOE is not considering venting configurations to constitute a consumer or product utility, consistent with the conclusions of the December 2021 Interpretive Rule. DOE acknowledges that certain types of homes may require substantial investment to upgrade the venting if transitioning from a Category I vent system to a Category IV vent system, and the Department aims to accurately capture these costs to the consumer in the LCC and PBP analyses. Additionally, DOE has considered a low-income consumer subgroup in order to assess the LCC impacts on access to affordable heating in particular. The details of these analyses are discussed in sections IV.F and IV.I of this document, respectively.

1. Screened-Out Technologies

Rheem suggested that hydrogen technology (including hydrogen and hydrogen blends) should be screened out from the technology options in this rulemaking due to technological feasibility. (Rheem, No. 37 at p. 3)

In response, DOE notes that in commenting on the March 2021 RFI, Rheem had recommended that the Department consider new fuel sources, including hydrogen-blended gas and renewable natural gas, while stating that industry groups are currently evaluating the safe and efficient use of hydrogen-blended fuels (with up to 15-percent hydrogen) in gas-fired appliances. (Rheem, No. 10 at p. 5) Consequently, DOE included hydrogen-ready boilers[34] in the technology assessment of the May 2022 Preliminary Analysis (*see* chapter 3 of the preliminary TSD). DOE evaluated hydrogen-ready boilers and differences in burner systems that would be able to accommodate a transition to hydrogen blend gas and has tentatively determined that hydrogen-ready burner designs do not appear to contribute to gains in AFUE. As a result of these findings, DOE did not consider hydrogen-ready burners in this NOPR as a technology option to improve consumer boiler AFUE, and, thus, this technology was not even included in the NOPR screening analysis. In addition, DOE notes that hydrogen-ready boilers do not appear to be commercially-available technologies in the United States, and have not yet been demonstrated to be commercially-viable and mass-produced, as per screening criteria number 2; therefore, even if hydrogen-ready burners were to provide an efficiency benefit to consumer boilers, this technology would have likely been screened out during this proposed rulemaking on the basis of practicability to manufacture, install, and service.

DOE requests further information on the potential future adoption of hydrogen-ready consumer boilers in the United States and any data demonstrating potential impacts of these burner systems on AFUE.

After consideration of each technology option analyzed in the technology assessment, DOE has screened out the following technologies in this NOPR analysis: condensing operation in oil-fired hot water boilers, pulse combustion, burner derating, low-pressure air-atomized oil burners, and control relays for models with BPM motors. DOE screened these technologies out in the May 2022 Preliminary Analysis for the

[34] "Hydrogen-ready" boilers are appliances that have the ability to burn both natural gas and hydrogen (*i.e.*, either a blend of the two fuels or a complete switch between fuels).

reasons explained in that document (*see* chapter 4 of the preliminary analysis TSD), but the Department did not receive any additional feedback from stakeholders on these determinations. Table IV.2 presents the criteria that were the basis for screening out each of these technologies from further consideration in the NOPR analysis. Further details can be found in chapter 4 of the NOPR TSD.

Table IV.2 Screened-Out Technologies for Consumer Boilers

Technology Option	EPCA Criterion (X = basis for screening out)				
	Technological Feasibility	Practicability to Manufacture, Install, and Service	Adverse Impacts on Utility or Availability	Adverse Impacts on Health and Safety	Unique-Pathway Proprietary Technologies
Condensing operation in oil-fired hot water boilers		X			
Pulse combustion				X	
Burner derating			X		
Low-pressure air-atomized oil burners		X			
Control relays for BPM motors			X		

DOE requests comment on the tentative determination that condensing operation in oil-fired hot water boilers, pulse combustion, burner derating, low-pressure air-atomized oil burners, and control relays for models with BPM motors should be screened out from further analysis.

2. Remaining Technologies

Through a review of each technology, DOE tentatively concludes that all of the other identified technologies met all five screening criteria to be examined further as design options to improve AFUE in DOE's NOPR analysis. In summary, DOE did not screen out the following technology options presented in Table IV.3.

Table IV.3 Retained Technologies for Consumer Boilers

Technology	
Type	**Design Option**
Fans / Venting	Inducer fans*
	Vent dampers
	Direct venting / power venting
Heat Exchanger Improvements	Condensing heat exchanger (for gas hot water boilers only)
	Improved geometry and increased heat exchanger surface area
	Baffles
Burner	Modulating operation / modulating Aquastats
	Premix burners
	Delayed-action oil pump solenoid valves
Ignition	Electronic ignition (for oil-fired boilers)

*In chapter 3 of the May 2022 Preliminary Analysis TSD, inducer fans were described as mechanical draft systems and grouped with heat exchanger improvements, as use of induced draft can allow for use of more restrictive heat exchanger designs that improve heat transfer.

DOE has initially 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 to improve AFUE 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, unique-pathway proprietary technologies).

By screening out control relays for models with BPM motors, DOE has tentatively determined that there remain no other technology options which could viably improve standby mode and off mode power consumption. As a result of this screening analysis, DOE has tentatively determined that it is not technologically feasible at this time to increase the stringency of the standby mode and off mode power consumption standards for consumer boilers.

For additional details, see chapter 4 of the NOPR TSD.

C. Engineering Analysis

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

As discussed in the previous section of this document, DOE has tentatively determined that it is not technologically feasible at this time to increase the stringency of the standby mode and off mode power consumption standards for consumer boilers because all of the potential technology options have either uncertain impact on $P_{W,SB}$ and

$P_{W,OFF}$ or have been removed from further consideration in the screening analysis. Thus, the engineering analysis of this NOPR assesses improvements in AFUE only.

AHRI supported the Department's preliminary decision not to analyze a more-stringent standard for standby and off mode power consumption, stating that there is limited benefit to setting a more-stringent standard. (AHRI, No. 40 at p. 4) Rheem also supported DOE's tentative determination not to analyze more-stringent standby mode and off mode standards. Rheem requested clarification as to whether DOE can simultaneously increase the minimum AFUE if that results in an increase in electrical energy consumption and a corresponding increase in standby mode and off mode energy use, even if the combined change results in a net decrease in energy use. (Rheem, No. 37 at pp. 3–4)

In response to the question from Rheem, EPCA states that the Secretary may not prescribe any amended standard which increases the maximum allowable energy use or decreases the minimum required energy efficiency of a covered product (which includes consumer boilers). (42 U.S.C. 6295(o)(1)) This statutory "anti-backsliding" provision would prohibit DOE from increasing the standby mode and off mode energy consumption standards.

The comment from Rheem appears to suggest that standards should consider a combined metric of both active mode, standby mode, and off mode energy consumption. EPCA requires integration of standby mode and off mode energy consumption "into the overall energy efficiency, energy consumption, or other energy descriptor for each covered product, with one exception being if such an integrated test procedure is technically infeasible for a particular covered product, in which case the Secretary shall prescribe a separate standby mode and off mode energy use test procedure for the covered product, if technically feasible. (42 U.S.C. 6295(gg)(2)(A)) In a final rule published in the *Federal Register* on October 20, 2010, DOE determined that an integrated metric is not technically feasible because the measurement of standby mode and off mode energy consumption is much smaller than the active mode fuel consumption reflected in AFUE, making the standby mode and off mode energy consumption infeasible to regulate as part of a combined metric. 75 FR 64621, 64622-64627.

From its own test data and manufacturer interviews, DOE has tentatively determined that increases to the AFUE of a boiler would not result in increases to the standby mode and off mode power consumption in such a way that it would be impossible to comply with the existing standby mode and off mode power consumption standards.

Additionally, as discussed in section III.C of this document, DOE's test method for consumer boilers assigns a value of 100-percent AFUE to any electric boiler which is non-weatherized (see section 11.1 of ASHRAE 103-2017, which is incorporated by reference into appendix EE). DOE has not identified any electric boilers that are weatherized or intended for installation outdoors, and has tentatively determined that electric boilers would typically be non-weatherized and installed indoors. As such, the AFUE for these products would already be at the maximum possible value per the test procedure. Thus, DOE did not further analyze electric hot water or electric steam boilers in the engineering analysis, and AFUE-based standards for these product classes are not proposed in this NOPR.

The following subsections outline the methodology used when conducting the efficiency analysis and cost analysis.

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 "gap fill" levels (to bridge large gaps between other identified efficiency levels) and/or to extrapolate to the max-tech level (particularly in cases where the max-tech level exceeds the maximum efficiency level currently available on the market).

In this proposed rulemaking, DOE has relied on the efficiency-level approach. This approach ensures that the efficiency levels considered in the engineering analysis are attainable using technologies which are commercially available and viable for consumer boilers, and DOE considered this approach reasonable because all of the technology options to improve AFUE that passed the screening analysis have been observed in commercially-available products. Additionally, as discussed later, since the consumer boiler industry is relatively mature, it exhibits a design option pathway to improved AFUE efficiency demonstrated by models on the market. As such, DOE was able to conduct teardown analyses on consumer boilers which meet each efficiency level, and ascertain a list of representative design options which manufacturers are most likely to employ in order to achieve these efficiencies. The selection of these efficiency levels from market data is discussed in the following sections.

a. Baseline Efficiency

For each product class, DOE generally selects a baseline model as a reference point for each class, and measures changes resulting from potential energy conservation standards against the baseline. The baseline model in each product class represents the characteristics of a product typical of that class (*e.g.*, capacity, physical size). Generally, a baseline model is one that just meets current energy conservation standards, or, if no standards are in place, the baseline is typically the most common or least efficient unit on the market. For consumer boilers, there currently exist minimum AFUE standards for gas-fired and oil-fired products at 10 CFR 430.32(e)(2)(iii)(A), which were used to define the baseline efficiency levels for these product classes. Additionally, baseline models must meet the design requirements at 10 CFR 430.32(e)(2)(iii)(A) and the standby mode and off mode power consumption standards at 10 CFR 430.32(e)(2)(iii)(B).

b. Higher Efficiency Levels

As part of DOE's analysis, the maximum available efficiency level is the highest efficiency unit currently available on the market. DOE also defines a "max-tech" efficiency level to represent the maximum possible efficiency for a given product. For this analysis, because the consumer boiler industry is relatively mature and there is a clear design option pathway to improved AFUE efficiency demonstrated by models on the market, DOE has tentatively determined that the maximum available efficiency level is representative of the max-tech efficiency level for gas-fired and oil-fired boilers, and that any additional design options that could theoretically be used to further improve efficiency have been screened out. The max-tech efficiency levels analyzed in the May 2022 Preliminary Analysis are provided in Table IV.4.

Table IV.4 Max-Tech AFUE Efficiency Levels for Consumer Boilers

Product Class	AFUE (%)
Gas-fired hot water	96
Gas-fired steam	83
Oil-fired hot water	88
Oil-fired steam	86

In the May 2022 Preliminary Analysis, DOE also considered the range of input capacities of models certified at these efficiencies to ensure that the max-tech efficiencies analyzed would not inadvertently correspond to a lessening of product availability to meet the full range of household heating needs (*see* chapter 5 of the preliminary analysis TSD). These assessments were made based on the database of consumer boilers constructed as part of the market assessment, discussed in section IV.A.2 of this document.

In response to the May 2022 Preliminary Analysis, AHRI noted that NFPA-31, "Standard for the Installation of Oil-Burning Equipment" (NFPA-31)[35], provides guidance for the relining of chimneys based on steady-state efficiency, and within these guidelines are restrictions on higher-efficiency oil boilers that AHRI stated may have an impact on consumers. AHRI commented that, according to NFPA-31, a 6-inch diameter by 35-foot long metal chimney liner can be used for an 86-percent "steady-state efficiency" boiler having an input between 119,000 and 280,000 Btu/h, but this input range becomes 140,000 to 210,000 Btu/h if the "steady-state efficiency" is 88-percent. As a result, AHRI recommended that DOE should treat 86.0-percent AFUE as max-tech for oil-fired hot water boilers. (AHRI, No. 40 at p. 4)

In response, DOE reviewed the 2020 edition of NFPA-31[36] and notes that Tables E.5.4(a) through E.5.4(e) of that standard present the chimney metal liner specifications that are appropriate for various firing rates (in terms of gallons of oil per hour), and DOE understands that AHRI has converted these values of oil firing rates into Btu/h input

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[35] NFPA-31 Appendix E states that metal chimney liners may be needed to reduce transient low draft during startup, as well as protect masonry from acidic condensate damage. The required size of the liner is specified based on the steady state efficiency of the boiler, which is shown in NFPA-31 Appendix E tables E.5.4(a) and E.5.4(b).
[36] Found online at *link.nfpa.org/free-access/publications/31/2020* (Last accessed Jan. 3, 2023).

rates. AHRI's comment indicates that, for a 6-inch diameter by 35-foot long chimney liner, a steady-state efficiency[37] greater than 86-percent could result in a smaller range of input capacities allowable. Upon further inspection of Table E.5.4(a) of NFPA-31, DOE notes that AHRI's calculation is based on a lateral run of 10 feet. Adjusting to a shorter horizontal vent run of 4 feet,[38] for example, would allow households to meet their heating needs using a boiler with a higher efficiency. Table E.5.4(a) of NFPA-31 indicates that a firing rate of 1.75 gallons per hour (approximately 245,000 Btu/h) is acceptable at the high end of firing rates for steady-state efficiencies of 88 percent, which DOE estimates would correspond to AFUEs of 87–88 percent. This would suggest that the narrowing of the acceptable input capacity range is not significant enough to mean that a large fraction of homes would not be able to find a replacement boiler to meet their heating needs if the standard were set at 88-percent AFUE.

Therefore, upon re-evaluating the input capacity ranges available for the maximum available AFUEs on the market, DOE has initially concluded that the max-tech levels from the May 2022 Preliminary Analysis are still applicable, and these levels were analyzed as max-tech in this NOPR.

Between the baseline efficiency level and max-tech efficiency level, DOE analyzed several other intermediate higher efficiency levels. In the May 2022 Preliminary Analysis, DOE sought comment on whether the AFUE efficiency levels

[37] Section E.8.3 of NFPA-31 suggests that the steady-state efficiency of a hydronic boiler can be estimated by adding 1 percentage point to the rated AFUE of the boiler.
[38] As discussed in appendix 8D of the NOPR TSD, most oil-fired boilers do not have a horizontal vent option, so the horizontal run would be limited for vertical venting.

identified at the preliminary stage were appropriate for each product class (see the Executive Summary of the preliminary TSD).

As discussed in section IV.B of this document, DOE received multiple comments regarding the 85-percent AFUE efficiency level which was analyzed for gas-fired hot water boilers in the May 2022 Preliminary Analysis. For the reasons explained in that section, the Department has tentatively determined that the concerns raised by stakeholders reflect potential downsides to these products regarding the installation, maintenance, and repair costs—and not a risk directly associated with incrementally more-efficient heat exchanger technologies. Hence, DOE has retained the 85-percent AFUE efficiency level in this NOPR analysis after observing that a substantial number of models on the market are certified at this level. This observation is further corroborated by AHRI's 2021 shipment data for consumer boilers, which indicate that boilers rated between 85.0-percent and 85.9-percent AFUE are the second-highest frequency of non-condensing model shipments, behind only baseline models (see AHRI, No. 42 at p. 2).

Crown provided a detailed analysis of how venting category requirements correlate to the flue gas temperature and percent of CO_2 in the flue gas, and described the approximate relationship between these parameters and the steady-state combustion efficiency of a consumer boiler. Reiterating comments provided in the previous rulemaking, Crown stated that there is a limit to the steady-state efficiency that is achievable while maintaining Category I venting status. (Crown, No. 30 at pp. 3–5) U.S. Boiler provided the same comments as Crown. (U.S. Boiler, No. 31 at pp. 3–5) DOE agrees with the assessment provided by Crown and U.S. Boiler and notes that, in the engineering analysis, design options to improve efficiency include technologies which would move the consumer boiler out of Category I venting status.

In response to the May 2022 Preliminary Analysis, Rheem suggested consideration of an additional efficiency level for gas-fired hot water boilers at 90-percent AFUE to capture a segment of the market certified by ENERGY STAR (at the minimum level under that program) with existing products on the market. (Rheem, No. 37 at p. 4)

In response, DOE notes that EPA's ENERGY STAR Product Specification for Boilers, Version 3.0 (effective October 1, 2014) (ENERGY STAR Product Specification V3.0) requires a minimum performance of 90-percent AFUE for gas-fired boilers and 87-percent AFUE for oil-fired boilers.[39] While the 87-percent AFUE efficiency level was already considered for oil-fired hot water boilers, the May 2022 Preliminary Analysis did not assess a 90-percent AFUE efficiency level for gas-fired hot water boilers. Therefore, in this NOPR analysis, DOE has added an efficiency level corresponding to the ENERGY STAR Product Specification V3.0 for gas-fired hot water boilers. Additional teardown analyses were conducted to assess the design options representative of this efficiency level, and further details are described in chapter 5 of the NOPR TSD.

The efficiency levels analyzed in this NOPR are shown subsequently in Table IV.5 through Table IV.8.

[39] ENERGY STAR Product Specification for Boilers, Version 3.0 can be found online at *www.energystar.gov/sites/default/files/specs/Boilers%20Program%20Requirements%20Version%203%200.pdf* (Last accessed Jan. 3, 2023).

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, and the availability and timeliness of purchasing the product on the market. The cost approaches are summarized as follows:

- *Physical teardowns:* Under this approach, DOE physically dismantles a commercially-available product, component-by-component, to develop a detailed bill of materials (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 bill of materials for the product.
- *Price surveys:* If neither a physical nor catalog teardown is feasible (for example, for tightly integrated products such as fluorescent lamps, which are infeasible to disassemble and for which parts diagrams are unavailable) or cost-prohibitive and otherwise impractical (e.g. large commercial boilers), DOE conducts price surveys using publicly-available pricing data published on major online retailer websites and/or by soliciting prices from distributors and other commercial channels.

In the present case, DOE conducted the analysis using physical and catalog teardowns to generate BOMs for models meeting the efficiency levels selected in the efficiency analysis. While the BOM generated for each model describe the product's construction in detail (*i.e.*, including each fabrication and assembly operation, types of parts that are purchased versus built in-house, types of equipment needed to manufacture the product, and manufacturing process parameters), any additional higher-cost features that were included in the consumer boiler design but do not have any impact on AFUE were not factored into the engineering analysis. Wherever possible, DOE compared models from similar product lines at different efficiencies in order to clearly identify the design option pathway to higher efficiency levels. Through these teardown analyses, DOE has found that the pathway for improving AFUE is relatively homogeneous across all boiler product classes and efficiency levels—consisting mainly of heat exchanger improvements.

The BOM provides the basis for the manufacturer production cost (MPC) estimates. DOE sought comment on the MPC estimates presented in the May 2022 Preliminary Analysis (see the Executive Summary of the preliminary TSD).

Crown and U.S. Boiler commented that manufacturing, installation, and operating costs used for DOE's preliminary analysis are likely obsolete due to recent sharp increases in prices (reflecting inflation and supply chain issues). Crown stated that if DOE were to raise the standards for gas-fired hot water boilers to a condensing efficiency level, it would result in significant increases in MPCs for gas steam and oil-fired cast-iron boilers even if the standards for those product classes remain unchanged due to the large, fixed costs for cast-iron foundries. Crown indicated that if standards for gas-fired hot water boilers were raised to a condensing efficiency level, the fixed costs of the foundries could no longer be shared between gas-fired hot water boilers and noncondensing gas steam and/or oil-fired boilers due to their significant differences in design. Such a scenario could render some foundries no longer financially viable. (Crown, No. 30 at pp. 5–6; U.S. Boiler, No. 31 at pp. 5–6) Similarly, WMT indicated that sectional cast-iron heat exchangers are nearly identical across product classes, so the potential elimination of non-condensing cast-iron gas-fired hot water boilers would significantly change the cost structure for other product classes. (WMT, No. 32 at p. 2)

In response, DOE's cost analysis accounts for the recent increases in material and part prices caused by inflation and supply chain challenges; specifically, prices from September 2022 were used for purchased parts and non-metals, and a five-year average up to September 2022 was used to account for raw metal prices (this average being a method to account for rapid fluctuations which typically average out in the future). For this NOPR and with regards to the potential changes in manufacturing cost due to cast-iron foundry impacts, DOE did not directly account for the pricing interaction across product classes described by Crown and U.S. Boiler for cast-iron boilers in the industry MPC estimates. DOE notes that many consumer boiler original equipment manufacturers (OEMs) have already transitioned to using foundries owned by companies unrelated to the particular consumer boiler OEM (*i.e.*, "third-party foundries") for their consumer boiler castings. Of the 10 consumer boiler OEMs that offer gas-fired steam, oil-fired hot water, or oil-fired steam cast-iron boilers, research indicates that only two OEMs currently own domestic foundries (*i.e.*, vertically integrated OEMs) that supply consumer boiler castings for the U.S. market. This would suggest that current component price estimates already reflect a transition in foundry operation. Although DOE did not directly account for the pricing interaction across product classes in the engineering analysis, DOE estimates the potential fixed foundry overhead and depreciation costs associated with producing gas-fired hot water boiler heat exchangers that may need to be reallocated to gas-fired steam, oil-fired hot water, and oil-fired steam production costs under a condensing standard and analyzes the potential impacts of a condensing standard on OEMs that operate their own foundries in section V.B.2.d of this document, "Impacts on Subgroups of Manufacturers."

DOE requests comment on whether an increase in MPCs for gas-fired steam, oil-fired hot water, and oil-fired steam boilers would result from an amended standard requiring condensing technology for gas-fired hot water boilers and, if so, how much of an increase would occur. DOE also requests comment on whether the potential increase in cast-iron boiler MPCs would only be applicable to consumer boiler manufacturers that operate their own foundries.

BWC requested that DOE re-evaluate the assumptions in Table 5.6.4 of the preliminary TSD ("Factory Parameter Assumptions"), which it argued appeared to be grossly overstated given the overall size of the boiler industry. (BWC, No. 39 at p. 3)

In addition to seeking public comment on the MPC estimates from the May 2022 Preliminary Analysis, DOE consultants discussed the results of the preliminary cost analysis with manufacturers in confidential interviews in order to solicit direct feedback on the MPCs. DOE incorporated a substantial amount of the qualitative and quantitative feedback obtained from manufacturers to refine the assumptions used in the cost modeling for this NOPR, as suggested by BWC. These updates are detailed in chapter 5 of the NOPR TSD, and include revisions to the factory parameter assumptions.

3. Manufacturer Markup and Shipping Costs

To account for manufacturers' non-production costs and profit margin, DOE applies a multiplier (the manufacturer markup) to the MPC. The resulting manufacturer selling price (MSP) is the price at which the manufacturer distributes a unit into commerce. DOE developed an average manufacturer markup by examining the annual Securities and Exchange Commission (SEC) 10-K reports[40] filed by publicly-traded manufacturers primarily engaged in heating, ventilation, and air conditioning (HVAC) manufacturing and whose combined product range includes consumer boilers. See chapter 12 of the NOPR TSD or section IV.J.2.d of this document for additional detail on the manufacturer markup.

Shipping costs account for the additional non-production cost for manufacturers to distribute their products to the first buyer in the distribution chain. In the May 2022 Preliminary Analysis, DOE estimated shipping costs based on how many units can fit in a typical trailer, considering the extra space necessary for shipping and loading inefficiencies for mixed truckload configurations with other equipment. In general, DOE found that shipping costs would not vary appreciably by efficiency level, except for gas-fired hot water boilers. For this product class, models with condensing heat exchangers would have more lightweight and compact designs, allowing for more products to

[40] U.S. Securities and Exchange Commission, *Electronic Data Gathering, Analysis, and Retrieval (EDGAR) system.* Available at *www.sec.gov/edgar/search/* (Last accessed Jan. 3, 2023).

potentially be loaded onto a trailer such that the shipping cost would decrease for condensing efficiency levels (*see* chapter 5 of the preliminary analysis TSD).

WMT commented that shipping costs have increased dramatically (in some cases nearly doubling or tripling the costs of shipping from pre-pandemic levels), and this would affect costs for components to ship to consumer boiler manufacturers, as well as the costs for consumer boilers to be shipped to customers. WMT stated that such shipping cost impacts should be included in DOE's analysis. (WMT, No. 32 at p. 9)

In response, DOE notes that the MPC estimates discussed in section IV.C.2 of this document account for the costs for components to ship to consumer boiler manufacturers. In general, through its review of publicly-available component cost data and confidential interviews with consumer boiler manufacturers, the Department has observed an increase in purchased component prices, which is reflected in the increase in MPCs in this NOPR analysis compared to the May 2022 Preliminary Analysis.

For outgoing shipping costs, DOE monitors trailer prices on a regular basis to ensure that these costs reflect the most recent freight shipping rates to transport products. DOE did observe a substantial increase in prices immediately following the COVID-19 pandemic and subsequent supply chain crisis,[41] and these increases were reflected in the shipping cost estimates in the May 2022 Preliminary Analysis. Many of the shipping costs estimated in this NOPR are comparable to the preliminary estimates in the May

[41] U.S. Bureau of Labor Statistics Producer Price Index (PPI) commodity data for transportation services indicate a sharp rise in long-distance motor carrying prices since 2020. *See* online at *data.bls.gov/timeseries/wpu301202&output_view=pct_12mths* (Last accessed Jan. 3, 2023).

2022 Preliminary Analysis; however, DOE did revise its approach for this NOPR. Instead of using a coast-to-coast distance estimate, which was used in the May 2022 Preliminary Analysis, DOE relied on a Midwest-to-coast distance estimate after careful review of the geographic locations of consumer boiler manufacturing sites. Therefore, although DOE included the most up-to-date trailer prices, this change in the shipping distance estimate caused the shipping costs for most product classes to be lower in this NOPR compared to the May 2022 Preliminary Analysis.

Crown and U.S. Boiler commented that condensing boilers are often imported fully assembled from Europe or Asia, and when they are not, the "heat engine" (heat exchanger and burner system) almost always is, with final assembly occurring in the United States. Crown indicated that the longer supply chain for condensing boilers would negate any savings in shipping costs due to the reduced size and weight of condensing boilers. (Crown, No. 30 at p. 6; U.S. Boiler, No. 31 at p. 6)

In response, DOE once again notes that as mentioned, inbound freight costs are included in the MPCs as a portion of the cost for purchased parts. In this analysis, based on further manufacturer feedback during interviews, DOE estimated MPCs associated with final assembly occurring in the United States. While developing the MPCs for consumer boilers in this NOPR, DOE incorporated recent manufacturer feedback to arrive at the most recent estimates for heat exchangers and burners purchased from overseas. Based on the results of the engineering analysis, DOE agrees with Crown and U.S. Boiler that the MPC plus shipping costs for condensing boilers will in total be higher than the MPC plus shipping costs for non-condensing boilers.

4. Cost-Efficiency Results

The results of the engineering analysis are reported as cost-efficiency data (or "curves") in the form of AFUE versus MPC and MSP (in 2022 dollars). DOE developed four curves representing the four consumer boiler product classes which are being analyzed in this NOPR. Manufacturing costs can vary with the input rating of the consumer boiler, and for each product class, one representative input capacity was chosen as the basis for analysis to represent the entire class: 100,000 Btu/h for gas-fired boilers and 140,000 Btu/h for oil-fired boilers. This allowed DOE to develop one curve to represent the cost of implementing engineering design changes for each product class. The methodology for developing the curves started with determining the MPCs for baseline products. Above the baseline, DOE determined the design options which would comprise the most cost-effective pathway to higher efficiency levels using teardown data at each level. See chapter 5 of the NOPR TSD for additional detail on the engineering analysis. The resulting cost-efficiency curves are shown in Table IV.5, through Table IV.8.

DOE requests comment on the cost-efficiency results in this engineering analysis. DOE also seeks input on the design options that would be implemented to achieve the selected efficiency levels.

Table IV.5 Cost-Efficiency Curve for Gas-Fired Hot Water Boilers

Efficiency Level	AFUE (%)	Design Options	MPC (*2022$*)	MSP (*2022$*)	Shipping Cost (*2022$*)
EL 0 (baseline)	84	Non-condensing heat exchanger; Natural or induced draft	581.22	819.52	30.32
EL 1	85	EL0 + Increased heat exchanger surface area; Natural or induced draft	645.20	909.73	30.32

Efficiency Level	AFUE (%)	Design Options	MPC (*2022$*)	MSP (*2022$*)	Shipping Cost (*2022$*)
EL 2 (ENERGY STAR V3.0)	90	Cast-aluminum or stainless-steel condensing heat exchanger; Premix modulating burner	991.66	1,398.24	18.53
EL 3	95	Stainless-steel condensing heat exchanger; Premix modulating burner	1,020.12	1,438.37	18.53
EL 4 (max-tech)	96	EL3 + Increased heat exchanger surface area with improvements in geometry	1,471.07	2,074.21	18.53

Table IV.6 Cost-Efficiency Curve for Gas-Fired Steam Boilers

Efficiency Level	AFUE (%)	Design Options	MPC (*2022$*)	MSP (*2022$*)	Shipping Cost (*2022$*)
EL 0 (baseline)	82	Cast-iron non-condensing heat exchanger; Natural or induced draft	781.76	1,102.28	38.59
EL 1 (max-tech)	83	EL0 + Increased heat exchanger surface area; Natural or induced draft	865.05	1,219.72	38.59

Table IV.7 Cost-Efficiency Curve for Oil-Fired Hot Water Boilers

Efficiency Level	AFUE (%)	Design Options	MPC (*2022$*)	MSP (*2022$*)	Shipping Cost (*2022$*)
EL 0 (baseline)	86	Cast-iron non-condensing heat exchanger; Power oil burner	1,198.85	1,690.38	48.60
EL 1 (ENERGY STAR V3.0)	87	EL0 + Increased heat exchanger surface area	1,244.66	1,754.97	48.60
EL 2 (max-tech)	88	EL1 + Increased heat exchanger surface area	1,289.64	1,818.39	48.60

Table IV.8 Cost-Efficiency Curve for Oil-Fired Steam Boilers

Efficiency Level	AFUE (%)	Design Options	MPC (*2022$*)	MSP (*2022$*)	Shipping Cost (*2022$*)
EL 0 (baseline)	85%	Cast-iron non-condensing heat exchanger; Power oil burner	1,182.48	1,667.30	62.79
EL 1 (max-tech)	86%	EL0 + Increased heat exchanger surface area; Baffles	1,287.50	1,815.38	62.79

D. Markups Analysis

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

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

For this NOPR, DOE characterized how consumer boiler products pass from the manufacturer to residential and commercial consumers[42] by gathering data from several sources, including consultant reports (available in appendix 6A) and a 2022 BRG report,[43] to determine the distribution channels and fraction of shipments going through each distribution channel. The distribution channels for replacement or new owners of

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[42] Based on available data, DOE estimates that 10 percent of hot water gas-fired boilers, 9 percent of steam gas-fired boilers, 13 percent of hot water oil-fired boilers, and 13 percent of steam oil-fired boilers will be shipped to commercial applications in 2030.

[43] BRG Building Solutions, The North American Heating & Cooling Product Markets (2022 Edition) (Available at: *www.brgbuildingsolutions.com/reports-insights*) (Last accessed Jan. 3, 2023).

consumer boilers in residential applications (not including mobile homes) are characterized as follows:[44]

Manufacturer ➔ Wholesaler ➔ Plumbing Contractor ➔ Consumer

Manufacturer ➔ Retailer ➔ Consumer

Manufacturer ➔ Retailer ➔ Plumbing Contractor ➔ Consumer

For mobile home replacement or new owner applications, there is one additional distribution channel as follows:[45]

Manufacturer ➔ Mobile Home Dealer/Retail Outlet ➔ Consumer

Mainly for consumer boilers in commercial applications (for both replacement and new construction markets), DOE considers an additional distribution channel as follows:

Manufacturer ➔ Wholesaler ➔ Consumer (National Account)

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[44] Based on available data, DOE estimates that for both gas-fired and oil-fired boilers, 95 percent goes through the wholesaler-contractor distribution channel, 5 percent goes directly from retailers to consumers, and 5 percent goes through retailers to contractors and to consumers.

[45] Based on available data, DOE estimates that for both gas-fired and oil-fired boilers, 80 percent goes through the wholesaler-contractor distribution channel, 5 percent goes directly from retailers to consumers, 5 percent goes through retailers to contractors and to consumers, and 10 percent goes through specialty retailers or dealers.

The new construction distribution channel can include an additional link in the chain—the builder. The distribution channels for consumer boilers in new construction[46] in residential applications (not including mobile homes) are characterized as follows:[47]

Manufacturer ➔ Wholesaler ➔ Plumbing Contractor ➔ Builder ➔ Consumer

Manufacturer ➔ Wholesaler ➔ Builder ➔ Consumer

Manufacturer ➔ Wholesaler (National Account) ➔ Consumer

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

Manufacturer ➔ Mobile Home Manufacturer ➔ Mobile Home Dealer ➔ Consumer

DOE developed baseline and incremental markups for each actor in the distribution chain. Baseline markups are applied to the price of products with baseline efficiency, while incremental markups are applied to the difference in price between baseline and higher-efficiency models (the incremental cost increase). The incremental

[46] Based on available data, DOE estimates that 18 percent of hot water gas-fired boilers, 4 percent of steam gas-fired boilers, 8 percent of hot water oil-fired boilers, and 1 percent of steam oil-fired boilers will be shipped to new construction applications in 2030.

[47] DOE believes that many builders are large enough to have a master plumber and not hire a separate contractor, and assigned 45 percent of consumer boiler shipments in new construction to this channel. DOE estimates that in the new construction market, 90 percent of the residential (not including mobile homes) and 80 percent of commercial applications go through a builder and that the rest go through the national account distribution channel.

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.[48]

To estimate average baseline and incremental markups, DOE relied on several sources, including: (1) form 10-K from the U.S. Securities and Exchange Commission (SEC) for Home Depot, Lowe's, Wal-Mart, and Costco (for retailers); (2) U.S. Census Bureau 2017 Annual Retail Trade Report for miscellaneous store retailers (North American Industry Classification System (NAICS) 453) (for online retailers),[49] (3) U.S. Census Bureau 2017 Economic Census data[50] on the residential and commercial building construction industry (for builder, plumbing contractor, mobile home manufacturer, mobile home retailer/dealer); and (4) the U.S. Census Bureau 2017 Annual Wholesale Trade Report data [51] (for wholesalers). DOE assumes that the markups for national account is half of the value of wholesaler markups. In addition, DOE used the 2005 Air Conditioning Contractors of America's (ACCA) Financial Analysis on the Heating, Ventilation, Air-Conditioning, and Refrigeration (HVACR) contracting industry[52] to

[48] 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.
[49] U.S. Census Bureau, *2017 Annual Retail Trade Report* (AWTR) (Available at: *www.census.gov/programs-surveys/arts.html*) (Last accessed January 3, 2023). Note that the 2017 Annual Retail Trade Report is the latest version of the report that includes detailed operating expenses data.
[50] U.S. Census Bureau, *2017 Economic Census Data* (Available at: *www.census.gov/programs-surveys/economic-census.html*) (Last accessed Jan. 3, 2023). Note that the 2017 Economic Census Data is the latest version of this data.
[51] U.S. Census Bureau, *2017 Annual Wholesale Trade Report* (AWTR) (Available at: *www.census.gov/wholesale/index.html*) (Last accessed Jan. 3, 2023). Note that the 2017 AWTR Census Data is the latest version of this data.
[52] Air Conditioning Contractors of America (ACCA), *Financial Analysis for the HVACR Contracting Industry* (2005) (Available at: *www.acca.org/store#/storefront*) (Last accessed Jan. 3, 2023). Note that the 2005 Financial Analysis for the HVACR Contracting Industry is the latest version of the report and is only used to disaggregate the mechanical contractor markups into replacement and new construction markets.

disaggregate the mechanical contractor markups into replacement and new construction markets for consumer boilers used in commercial applications.

In addition to the markups, DOE obtained State and local taxes from data provided by the Sales Tax Clearinghouse.[53] These data represent weighted-average taxes that include county and city rates. DOE derived shipment-weighted average tax values for each State considered in the analysis.

BWC stated that it is not aware of any boiler manufacturer that is selling direct to consumers, for both new construction and replacement, and that it is possible that some boilers are being sold from a manufacturer to a mechanical contractor followed by the consumer. BWC stated that it does not see boilers being sold from a manufacturer to a wholesaler and then to a builder and consumer, as a contractor would still need to be involved for the installation. (BWC, No. 39 at p. 3) Based on available data sources, DOE estimated that the majority of the contractors obtain boilers from wholesaler or retailer stores. DOE acknowledges that contractors are needed for installations, and for the new construction distribution channel without contractors, the assumption is that the builders have in-house contractors.

Rheem noted that not only do the percentages in Table 6.2.3 of the preliminary analysis TSD not add up to 100, but the manufacturer markup is also inconsistent throughout the analysis, with different values in the comment request and Tables 6.9.1,

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[53] Sales Tax Clearinghouse Inc., *State Sales Tax Rates Along with Combined Average City and County Rates* (Jan. 4, 2022) (Available at: *www.thestc.com/STrates.stm*) (Last accessed May 3, 2023).

6.9.2, and 6.9.3. (Rheem, No. 37 at p. 4) DOE acknowledges that the percentages in Table 6.2.3 and manufacturer markup values in Tables 6.9.1, 6.9.2, and 6.9.3 of the preliminary analysis TSD were incorrectly reported and they have been fixed in the NOPR TSD. The actual values applied in the analysis remain the same between the preliminary and NOPR analysis.

AGA, APGA, and NPGA stated that DOE should put greater weight on *ex post* and market-based evidence of markups to project a more realistic range of likely effects of a standard on prices, including the possibility that prices may fall. (AGA, APGA, and NPGA, No. 38 at p. 4) In response, DOE is not aware of any non-proprietary data that would allow estimation of changes in actual markups on consumer boilers. Regarding the effect of standards on prices, one study in 2013 that compared predicted and observed prices for nine products found that costs after standards, after adjusting for inflation, were less than what DOE estimated.[54] In the case of consumer boilers, DOE compared retail prices before and after the 2021 standards took effect and found that on average, actual consumer boiler retail prices were below what DOE estimated after adjusting for inflation. (See appendix 6A of the NOPR TSD for further details) Such comparisons are problematic, however, because a number of factors can cause prices to change, in addition to new efficiency standards. To serve the goal of DOE's analysis to specifically estimate the cost to consumers of new or amended energy conservation standards, DOE's

[54] Steven Nadel and Andrew deLaski, Appliance Standards: Comparing Predicted and Observed Prices (July 30, 2013) ACEEE and ASAP (Available at: *www.aceee.org/research-report/e13d*) (Last accessed Jan. 3, 2023).

method of estimating incremental costs relative to a baseline product is more likely to yield relevant results.

Chapter 6 of the NOPR TSD provides details on DOE's development of markups for consumer boilers.

E. Energy Use Analysis

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

DOE estimated the annual energy consumption of consumer boilers at specific energy efficiency levels across a range of climate zones, building characteristics, and applications. The annual energy consumption includes the natural gas, liquid petroleum gas (LPG), fuel oil, and electricity used by the consumer boilers. DOE's assessment of annual energy consumption is calculated for all households or buildings using a consumer boiler intended for space heating. In addition, DOE also included the annual energy consumption for a fraction of consumer boilers that are used to provide hot water in addition to space heating. DOE does not account for other potential boiler uses such as snow melt systems, pool or spa heating, or steam or hot water production for industrial or commercial processes, since currently DOE does not have any information about the market share and energy use of such systems to include it in its analysis.

The energy used by a consumer boiler when installed will vary by household or building characteristics, usage, and region. For this proposed rulemaking, the energy use for consumer boilers is estimated by identifying the various households or buildings in RECS and CBECS dataset that utilize consumer boilers covered by this proposed rule. Next, DOE used the same datasets to identify the space and water heating load for each of the buildings within the sample, which was used to determine the size of the commercial water heating equipment needed to meet the space and water heating need of the households or buildings being analyzed. The determination of the boiler capacity of a sampled household or building is based on heating load sizing calculations from industry reference manuals such as Manual J coupled with the above building characteristics and climate data. Households or buildings with higher heating requirements need larger capacity boilers per this sizing calculation. These households or buildings are then rank ordered to match available industry and market research shipment data by boiler capacity, so that the analysis has an informed distribution of boiler capacities that matches industry shipment data and larger capacity boilers are preferentially assigned to households or buildings with higher heating loads.

In order for energy use of the equipment to be determined, DOE calculated the time the boiler is spent in active mode (providing space heating or hot water to meet the load of the building) and in standby mode (electrical components are on but the boiler is not actively heating water). Starting from this energy consumption estimate, the heating load is further refined based on building characteristic data also included in RECS and CBECS, such as the building square footage, building vintage, foundation type, number of floors, and outdoor temperature (i.e., climate for a given region of the country). Certain building shell characteristics (e.g. insulation) are inferred based on the building's age and building shell indices from AEO 2023 dataset. The efficiency of the existing boiler for each household or buildings is estimated based on informed assumptions about the reported boiler age and historical efficiency distributions. The energy use is further adjusted by informed assumptions to reflect the impact of the return water temperature, which is discussed below in more detail below, as well as more minor effects such as jacket losses.

Chapter 7, appendix 7A, and appendix 7B presents further detail regarding the boiler sizing methodology and estimation of energy consumption.

DOE requests comment on DOE's space heating and water heating energy use methodology. DOE would also appreciate feedback, information, and data on these additional system types and processes that use consumer boilers (such as snow melt systems, pool or spa heating, or steam or hot water production for industrial or commercial processes).

Chapter 7 of the NOPR TSD provides details on DOE's energy use analysis for consumer boilers.

1. Building Sample

To determine the field energy use of consumer boilers used in homes, DOE established a sample of households using consumer boilers from EIA's 2015 Residential Energy Consumption Survey (RECS 2015),[55] which is the most recent such survey that is currently fully available. The RECS data provide information on the vintage of the home, as well as space heating and water heating energy use in each household. DOE used the household samples not only to determine boiler annual energy consumption, but also as the basis for conducting the LCC and PBP analyses. DOE projected household weights and household characteristics in 2030, the anticipated first year of compliance with any amended or new energy conservation standards for consumer boilers. To characterize future new homes, DOE used a subset of homes in RECS 2015 that were built after 1990.

To determine the field energy use of consumer boilers used in commercial buildings, DOE established a sample of buildings using consumer boilers from EIA's 2018 Commercial Building Energy Consumption Survey (CBECS 2018), which is the most recent such survey that is currently fully available. See appendix 7A of the NOPR TSD for details about the CBECS 2018 sample.

In commenting on the May 2022 preliminary analysis, WMT expressed concern about the level of accuracy in RECS 2015 data due to the substantial update to the end-

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[55] Energy Information Administration (EIA), 2015 Residential Energy Consumption Survey (RECS) (Available at: *www.eia.gov/consumption/residential*) (Last accessed Jan. 3, 2023). Note that RECS 2020 building characteristics have been released in preliminary form by EIA; however, the full release of RECS 2020 data was still not published when the analysis was conducted (expected to be published on June 2023).

use modeling and calibration methods described by EIA as having been implemented in this dataset. WMT noted that EIA removed unusually small or large outliers from the dataset, and that the variation in the data should be quantified to determine whether the data is actually representative of home sizes in the United States. WMT also commented that RECS estimates the energy used by boilers but does not include a reference to the actual energy use data used to validate these models, and, thus, this data may not accurately estimate the impact of proposed minimum efficiency levels relative to the base case energy consumption. WMT concluded that any LCC analysis based upon RECS must include the documented variation in the RECS dataset, as identified by EIA. (WMT, No. 32 at pp. 9-10)

In response, DOE notes that EIA administers the RECS to a nationally representative sample of U.S. housing units. For RECS 2015, specially trained interviewers collected energy characteristics on the housing unit, usage patterns, and household demographics. This information is combined with data from energy suppliers to these homes to estimate energy costs and usage for heating, cooling, appliances, and other end uses. The RECS survey data, including energy use, is an integral ingredient of EIA's *Annual Energy Outlook* (*AEO*) and Monthly Energy Review (MER). EIA's methodology for RECS 2015 is described in multiple reports.[56] As described in these reports, RECS 2015 represents a substantial update to the end-use modeling and calibration methods. For example, in the 2015 RECS, the end-use models follow an engineering approach, and the calibration—which follows a minimum variance

[56] See *www.eia.gov/consumption/residential/data/2015/index.php?view=methodology* (Last accessed Jan. 3, 2023).

estimation approach—is based on the relative uncertainties of and correlations between the end uses being estimated. Instead of estimating unknown parameters and interpreting their solution values as in statistical modeling, engineering models improve upon statistical models by drawing on existing studies. Also, engineering models lead to more realistic variations across modeled housing units. In addition, calibration procedures in RECS 2015 use minimum variance estimation, which better incorporates household characteristics data uncertainty and recognizes correlations between end uses. DOE notes that households that use natural gas, propane, or fuel oil predominately use these fuels for space heating and water heating. In the case of space heating, it is heavily seasonal, while water heating remains more constant throughout the year.

DOE determined the 95-percent confidence level for the average energy use values used in its analysis for consumer boilers to be plus or minus 7.2 percent, using EIA's methodology for calculating sampling error.[57] DOE also compared the RECS 2015 energy consumption estimates for boilers to previous RECS energy consumption estimates and other available studies for consumer boilers, and the Department found that energy consumption values estimated in 2015 are similar (or within in the RECS 2015 sampling error) of those other sources, after being adjusted for heating degree-day differences, building shell changes in the stock, and average boiler efficiency in the stock. This analysis included comparing homes using consumer boilers by home sizes and type in the different studies, including larger sample sized studies at the national level such as

[57] See *www.eia.gov/consumption/residential/data/2015/pdf/microdata_v3.pdf* (Last accessed Jan. 3, 2023).

the 2021 American Community Survey (ACS),[58] the 2021 American Housing Survey (AHS),[59] the 2022 American Home Comfort Study,[60] as well as regional studies such as the 2016-2017 Residential Building Stock Assessment (RBSA) for the northwest region (Idaho, Montana, Oregon, and Washington),[61] the 2019 Residential Building Stock Assessment for the State of New York,[62] the Massachusetts Residential Baseline Study,[63] and the 2019 California Residential Appliance Saturation Study (RASS).[64] In conclusion, DOE finds that RECS 2015 matches other studies' energy use estimates for boilers and is a reliable source for DOE to use to create a representative national sample reflecting variations in real world energy use. See appendix 7A and 7B of the NOPR TSD for more details.

AHRI and Rheem expressed concern with the Department using allegedly outdated data for the analysis, and these commenters stated that it is not a valid assumption that the market has remained unchanged since 2012 or 2015, and that the use of such data in the final rule will not be representative of impacts on consumers. AHRI

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[58] U.S. Census Bureau, 2021 American Community Survey (Available at: *www.census.gov/programs-surveys/acs*) (Last accessed Jan. 3, 2023).
[59] Department of Housing and Urban Development (HUD) and U.S. Census Bureau, 2021 American Housing Survey (Available at: *www.census.gov/programs-surveys/ahs.html*) (Last accessed Jan. 3, 2023).
[60] Decision Analyst, 2022 American Home Comfort Study (Available at: *www.decisionanalyst.com/syndicated/homecomfort/*) (Last accessed Jan. 3, 2023).
[61] NEEA, 2016-2017 Residential Building Stock Assessment (Individua Reports for Single Family, Manufactured Homes and Multifamily Homes) (Available at: *neea.org/data/residential-building-stock-assessment*) (Last accessed Jan. 3, 2023).
[62] NYSERDA, 2019 Residential Building Stock Assessment (Available at: *www.nyserda.ny.gov/About/Publications/Building-Stock-and-Potential-Studies/Residential-Building-Stock-Assessment*) (Last accessed Jan. 3, 2023).
[63] Electric and Gas Program Administrators of Massachusetts, Massachusetts Residential Building Use and Equipment Characterization Study (Available at: *ma-eeac.org/wp-content/uploads/Residential-Building-Use-and-Equipment-Characterization-Study-Comprehensive-Report-2022-03-01.pdf*) (Last accessed Jan. 3, 2023).
[64] CEC, 2019 California Residential Appliance Saturation Study (Available at: *www.energy.ca.gov/publications/2021/2019-california-residential-appliance-saturation-study-rass*) (Last accessed Jan. 3, 2023).

and Rheem encouraged the Department to update its analysis to use the CBECS 2018 data and to use the RECS 2020 data as soon as it becomes available. In addition, AHRI and Rheem recommended that DOE conduct updated surveys, studies, and analyses where the existing data sources are out of date. (AHRI, No. 40 at p. 5; Rheem, No. 37 at pp. 4-5) BWC commented that throughout the TSD, numerous references are made to what it perceived to be outdated surveys and other data sources. BWC stated that the reality of today's costs to consumers and manufacturers are significantly beyond what they were just a few years ago, let alone more than a decade ago. Accordingly, BWC strongly recommended that DOE should conduct surveys or studies to obtain the information necessary to properly inform major regulatory policy decisions. (BWC, No. 39 at p. 3)

In response, DOE notes that for this NOPR, it used the most recent data that was available. While conducting the preliminary analysis, RECS 2020 and CBECS 2018 were not fully available and did not have energy consumption estimates. However, DOE did incorporate CBECS 2018 for this NOPR and updated the weighting for residential sample based on RECS 2020. To confirm sample weighting using RECS 2020 and CBECS 2018, DOE also reviewed trends from multiple sources including Home Innovations data, American Home Comfort Survey data, and the American Housing Survey (AHS) to determine any changes in occupant density and types of home, changes in the housing stock by region, new construction trends, and changes in the types of water heater used by region and market segment. Regarding conducting independent surveys, DOE does not have the capacity to conduct nationally-representative surveys with sufficiently large sample sizes to provide useful results, on the same level as RECS and

CBECS. However, as stated previously, DOE compared its energy use model results to multiple studies, including NEEA data, RASS data, and multiple other residential boiler studies and determined that its methodology for assessment of the current market is appropriate.

Crown and U.S. Boiler stated that DOE is significantly overestimating the number of residential boilers used in commercial buildings, which inflated the estimate of energy savings that would result from adoption of a new standard. They also stated that while most of the buildings in the CBECS sample may indeed have multiple boilers, they are far more likely to have multiple commercial boilers than DOE has assumed. Crown and U.S. Boiler stated that the preliminary TSD indicates that DOE assumed that half of all buildings over 10,000 square feet that are heated with boilers use commercial boilers and the other half use residential boilers, but these commenters argued that DOE has provided no rationale for this breakdown. (Crown, No. 30 at p. 6; U.S. Boiler, No. 31 at p. 6)

In response, DOE revised its estimates of the number of consumer boilers in commercial buildings based on available shipment data from the 2022 BRG Building Solutions report,[65] the updated 2018 CBECS sample, and revised sizing methodology for boilers in commercial buildings. This resulted in a decrease in the fraction of commercial buildings above 10,000 square feet that use consumer boilers from 50 percent to 22 percent. See appendix 7A of the NOPR TSD for more details.

[65] BRG Building Solutions, The North American Heating & Cooling Product Markets (2022 Edition) (Available at: *www.brgbuildingsolutions.com/reports-insights*) (Last accessed Jan. 3, 2023).

DOE requests comment on DOE's methodology for determining the fraction of consumer boilers used in commercial buildings. DOE also seeks input regarding the fraction of consumer boilers in commercial buildings larger than 10,000 square feet.

Crown and U.S. Boiler stated that residential steam systems are obsolete and that the newest residential steam systems in the U.S. were installed long before 1970, so all residential steam boilers sold in the U.S. for space heating are, therefore, used in replacement installations. They stated that in some cases, oil steam boilers are replaced with gas steam boilers, making them "new owner" installations. Crown and U.S. Boiler stated that it is reasonable to expect the stock of buildings heated by residential steam heating boilers and steam boiler sales to decline over time. (Crown, No. 30 at p. 6; U.S. Boiler, No. 31 at p. 6) Crown's and U.S. Boiler's statements are consistent with DOE's sample development for steam boilers, as discussed further in sample variables in appendix 7A and in the shipments analysis in appendix 9A of the NOPR TSD.

2. Space Heating Energy Use

To estimate the annual energy consumption of consumer boilers, DOE first calculated the heating load based on the RECS and CBECS estimates of the annual energy consumption of the boiler for each household or commercial building. DOE estimated the house or building heating load by referencing to the existing boiler's characteristics, specifically its capacity and efficiency (AFUE), as well as the heat generated from the electrical components. The AFUE of the existing boilers was determined using the boiler vintage (the year of installation of the product) from RECS and historical data on the market share of boilers by AFUE.

DOE adjusted the AFUE of the existing and new boilers to reflect the variation in efficiency in different hydronic space heating applications by associating a specific space heating application with each sampled household or building. The field-adjusted AFUE of the existing and new boilers was calculated depending on the return water temperature, automatic means for adjusting water temperature, and jacket losses.

a. Heating Load Calculation

DOE estimated the house/building heating load by using the energy use estimates from RECS and CBECS for each consumer boiler and then assigning an existing boiler's characteristics, specifically its capacity and efficiency (AFUE). If DOE assigned multiple consumer boilers to a building, then the heating load was divided equally to each boiler. DOE then adjusted the energy use to normalize for weather by using long-term heating degree-day (HDD) data for each geographical region.[66] DOE also accounted for changes in building shell characteristics between 2015 (for RECS data) or 2018 (for CBECS data) and 2030 by applying the building shell efficiency indices in the National Energy Modeling System (NEMS) based on EIA's *Annual Energy Outlook 2023* (*AEO 2023*).[67] DOE also accounted for future heating season climate based on *AEO 2023* HDD projections.

WMT stated that DOE's analysis does not represent the portion of the insufficiently insulated homes and buildings for which condensing boilers would operate

[66] National Oceanic and Atmospheric Administration, NNDC Climate Data Online (Available at: *www.cpc.ncep.noaa.gov/products/analysis_monitoring/cdus/degree_days/*) (Last accessed Jan. 3, 2023).
[67] EIA, *Annual Energy Outlook 2023 with Projections to 2050,* Washington, DC (Available at: *www.eia.gov/forecasts/aeo/*) (Last accessed May 3, 2023).

continuously at high fire and yet may be unable to provide adequate heat on the coldest days. WMT stated that the practical impact of the variation in insulation quality across the country is that the annual operating cost of boilers in underserved and disadvantaged portions of society is understated in the current model, because the burner operating hours (BOH) modeled in the LCC analysis will not adequately represent the actual energy consumed to heat homes with insufficient insulation. WMT stated that the BOH approach modeled minimizes this concern through the "building envelope" approach described in the Technical Support Document, but neither the RECS nor the CBECS data address such insulation concerns adequately, and, therefore, these subgroups must be evaluated at the State and local level in addition to the national level. (WMT, No. 32 at pp. 5-6)

In response, DOE's equipment sizing approach considers the same maximum output capacity for both non-condensing and condensing equipment, and the level of heat provided in the coldest days is assumed to be the same for the baseline and higher efficiency equipment. However, installing contractors typically oversize the equipment significantly so that the boiler is able to meet the heating load demand on the coldest days. If a contractor decided to oversize the condensing equipment, then this could lead to increased energy use for the condensing equipment (but not necessarily increased burner operating hours, since larger output capacity could result in similar or decreased operating hours). DOE argues, though, that this additional energy use to be able to meet the heating load in the coldest days for an insufficiently insulated home or building would lead to greater comfort for the occupant and would lead to an unfair comparison to the non-condensing baseline model, since the installing contractor could also oversize the non-condensing model to achieve a similar result.

DOE notes that there may be a significant number of insufficiently insulated homes and buildings in the U.S., but RECS and CBECS already account for the higher energy use associated with heating these buildings in their energy consumption and expenditure data. The number of insufficiently insulated homes and buildings has decreased over time because of retrofit efforts (such as weatherization programs for low-income households) and the decreasing number of older homes in the building stock as some older homes get demolished. DOE relies on "building envelope" projections from *AEO 2023* to account for continued improvements to the insulation of homes and buildings, which accounts for changes in the building codes over time as well. For the NOPR analysis, DOE maintained its equipment sizing approach and approach for projecting changes in "building envelope," as used in the preliminary analysis.

b. Impact of Return Water Temperature on Efficiency

Consumer boilers need a low return water temperature (RWT) to condensate the hot flue gas and operate efficiently, as designed. When operating at a high RWT, consumer may lose the efficiency advantage. Considering the varying conditions in the installations, DOE accounted for boiler operational efficiency in specific installations by adjusting the AFUE of the sampled boiler based on an average system return water temperature. The criteria used to determine the return water temperature of the boiler system included consideration of building vintage, product type (condensing or non-condensing, single-stage or modulating), and whether the boiler employed an automatic means for adjusting water temperature. Using product type and system return water temperature, DOE developed and applied the AFUE adjustments based on average heating season return water temperatures.

BWC expressed concern with DOE using a curve fit of curves represented by various manufacturers showing the relationship of boiler efficiency versus RWT when the efficiency values represented were not verified by a third party, and it cannot be guaranteed that all these manufacturers characterized the boiler efficiencies in the same way. (BWC, No. 39 at p. 4) On this point, DOE notes that for the preliminary analysis, it used all the available data from the 2016 Final Rule (including data provided by Burnham in the 2015 NOPR for non-condensing and condensing boilers) to determine the impact of return water temperature on boiler efficiency. For this NOPR, DOE did not find any additional third-party testing data to justify changing its approach. DOE collected data on several more models, and these sources indicate a decrease similar to that encountered in the previous data DOE used.

DOE requests comments, information, and data regarding the relationship between boiler efficiency and return water temperature.

Crown and U.S. Boiler pointed to DOE's thermal efficiency versus RWT graphs converging into a narrow band between 86 percent and 88 percent as the RWT approaches 140°F as supporting their position that the AFUE of a condensing boiler operating above the dew point is largely independent of the rated efficiency in condensing mode. (Crown, No. 30 at p. 7; U.S. Boiler, No. 31 at pp. 7-8) In response, DOE would point out that although the regression analysis does show a narrow band at temperatures at or above 140°F RWT, there is still a differential between the three condensing efficiency levels, and that the graph presents the extent of the efficiency decreases in different temperature ranges. Consequently, DOE contends that it is not accurate to portray estimated condensing boiler efficiency above dew point as independent of rated efficiency.

BWC commented that DOE stated in the preliminary analysis TSD that a single-stage condensing boiler rated without automatic means or a condensing boiler (either two-stage or modulating) with automatic means, would have a field-adjusted efficiency above 90 percent AFUE in a high RWT system (160°F), a result which does not seem possible when an RWT above 130°F would prevent the boiler from condensing, and as such, its maximum expected efficiency would range from 85-percent to 88-percent AFUE. (BWC, No. 39 at pp. 3-4) Crown and U.S. Boiler stated that the current DOE assumption that adjustments for return water temperature are additive and constant relative to the rated AFUE at 120°F RWT. According to the commenters, this correction leads to a 95-percent AFUE modulating condensing boiler having a field-adjusted AFUE of 92.94 percent at 140°F RWT, a result which Crown and U.S. Boiler characterized as being unreasonable and highly optimistic. (Crown, No. 30 at p. 7; U.S. Boiler, No. 31 at pp. 7-8) Crown and U.S. Boiler also stated that any “AFUE adjustments” that are made should have a sound technical basis, or not be made at all. Crown and U.S. Boilers agreed with DOE that actual energy use for a boiler having a given rated AFUE will vary from one installation to the next based upon many factors, but stated that DOE’s attempt to adjust the rated AFUE to account for these varying field conditions is flawed and generally tends to overstate the efficiency of condensing boilers relative to non-condensing boilers. (Crown, No. 30 at p. 7; U.S. Boiler, No. 31 at p. 7)

In response to Crown's and U.S. Boiler's comments, DOE reviewed its field-adjusted AFUE values and compared them with the latest available field data. Based on this data (see appendix 7B of the NOPR TSD for details), DOE was able to refine field-adjusted AFUE by taking into account differences in local weather conditions, equipment sizing, heat emitter types, return water temperatures, and other installation characteristics for each sampled household or building. Overall, DOE found that modulating condensing boilers are able to match the heating load even if they are significantly oversized, compared to non-modulating equipment that might short-cycle more often if significantly oversized, which would impact efficiency. DOE also notes that current modulating condensing boilers with outdoor reset controls are able to handle a significant fraction of the heating load during typical winter conditions, even if the heat emitters are not properly sized. On average, the field-adjusted AFUE used in the preliminary analysis is similar to the field-adjusted efficiency for the NOPR, but the updated approach provides a more significant level of variability that is found in the field. See appendix 7B of the NOPR TSD for more details.

WMT stated that the vast majority of current boiler installations operate at 180°F circulating (return) water temperatures and that the prevalence of such boiler systems should be accounted for in the analysis. The commenter likewise argued that a related reduction in efficiency (for condensing boilers where additional emitter surface area is not added) should be accounted for in the analysis. WMT also stated that higher efficiencies are only consistently realized when the heat emitter surface area is adequately sized, because when it is not adequately sized, increased efficiencies are highly dependent upon the local climate. (WMT, No. 32 at p. 5) AHRI stated that according to a contractor survey they conducted, when replacing a non-condensing boiler with a condensing boiler, heat emitters are not being added in the field due to the cost of additional heat emitters or installation space constraints. Therefore, AHRI argued that DOE overstated the energy savings in its model, because such installations provide less than the stated efficiency levels, and the boilers would have to run longer to maintain home temperatures. (AHRI, No. 42 at p. 4)

In response, DOE agrees that many existing hydronic distribution systems were originally designed to meet the heating load on the coldest day, with the hot water circulating through the heat emitters (such as radiators) at 180°F. Based on weather data, boilers today typically experience conditions[68] at design limits less than five percent of the time when fulfilling space heating needs. The conditions that boilers usually face are considerably less than design during the rest of the year. By using bin data, DOE estimated that for most consumer boiler installations, for 80 percent or more of the heating season, boilers are required to consume 50 percent or less energy than the BTUs needed to meet designed maximum heating needs. In addition, the heating system (including the boiler and the installed radiator) is typically oversized significantly compared to the design conditions, and a significant number of buildings have improved

[68] The space heating design outdoor temperature is typically defined as the temperature point above which the actual ambient temperature would be for 99 percent of all the hours in the year, based on a 30-year average. In other words, at the space heating design temperature, the boiler would be expected to encounter colder temperatures for only 1 percent of the hours in a year.

their building shell in comparison to when the original hydronic heating system was originally installed. Condensing boilers also use outdoor reset features to calculate the right water temperature for the heat emitters based upon the load that the house or building is experiencing. DOE analyzed the design conditions, reset curves, and bin data for different houses or buildings in DOE's sample and determined that for a large majority of the heating season, the boiler can lower the water temperature so that the return temperatures coming back to the boiler are below combustion gas dewpoint levels,[69] which allows the boiler flue gases to condense and the boiler to operate at or near its rated efficiency. Another feature of condensing boilers is that the burner modulates, which typically increases the overall efficiency of the unit by allowing it to operate the majority of the time in part-load, which is typically at or near its rated efficiencies. In an ideal situation, the heat emitter for a condensing boiler installation is chosen to provide all the BTUs needed. For this to occur, all of the existing homes and commercial buildings would have to change and/or upgrade their existing heat emitters. As shown in AHRI's 2022 contractor survey, although upgrading the heat emitter does occur in the field to some extent, the majority of the time it does not. Therefore, for the NOPR, DOE updated its energy use model to estimate the fraction of the time the condensing boiler would operate at different efficiencies based on return water temperature by using binned weather data for each household or building installation. Such approach should allow DOE to characterize the impact of individual installations

[69] For example, when a condensing boiler is designed for 180°F water, 70°F indoors, and a design outdoor temperature of between 0°F and 10°F, the reset curve will calculate a water temperature that provides return temperatures below the dewpoint of the flue gases. Such mechanism would be expected to work as intended down to 25°F in order to ensure that the boiler is operating in a condensing mode.

more accurately, but on average, the Department has found the resulting efficiencies to be similar to the ones estimated in the preliminary analysis.

DOE requests comment on DOE's updated methodology for determining energy use for condensing boilers in different return water temperature applications.

c. Impact of Jacket Losses on Energy Use

In its analysis, DOE accounted for jacket losses when the boiler is located in a non-conditioned space (*i.e.*, unconditioned basement or garage). For boilers located in conditioned spaces, DOE assumed that jacket losses contribute to space heating as useful heat.

Crown and U.S. Boiler stated that there is little justification in applying jacket loss to any boilers installed in basements, especially when the DOE test procedure treats non-weatherized boilers as being located indoors in a conditioned space, consistent with long-standing DOE practice. Crown and U.S. Boiler also pointed out that there may be a problem with the two jacket loss factors K and C_J being inconsistent with each other in ASHRAE 103-2017. (Crown, No. 30 at p. 8; U.S. Boiler, No. 31 at p. 8)

In response, because some of the jacket losses could contribute to heating the conditioned space, DOE maintains that the jacket loss adjustment values are only applied to installations in unconditioned basements. In regard to the jacket loss values, since there are very limited test data, for the NOPR, DOE revised its jacket loss value for condensing boilers so that it is equal to on average 0.5 (per ASHRAE 103-2022 for finned-tube boilers, which would more closely approximate condensing boiler designs, and DOE assumed 0.5 percent for the jacket loss fraction.

d. Impact of Excess Air Adjustments

A properly controlled amount of excess air provided to the boiler during operation helps with efficient combustion and safe venting, but will impact the efficiency of the boiler if the excess air becomes too much. The current DOE test procedure requires the burners of gas-fired boilers to be adjusted to their maximum Btu input ratings at the normal pressure and to set the primary air shutters in accordance with the manufacturer's recommendation to give a good flame. However, as many consumer boilers operate on the lower end of the firing rates in the field, the excess air level calibrated at high fire decreases the operational efficiency. For the preliminary analysis, DOE accounted for differences in excess air between the test procedure and field conditions; DOE assumed that the increased excess air level in the field would be based on the assumed stack temperature and draft type, and addressed this by reducing AFUE by an adjustment factor ranging from 0.0 percent to 1.6 percent.

Crown and U.S. Boiler stated that DOE's "excess air adjustment" adds error to the analysis and needs to be dropped. Crown and U.S. Boiler stated that because DOE's test procedure does not require gas burner excess air to be adjusted in accordance with manufacturer's instructions, and because excess air on non-atmospheric gas burners can often be adjusted independently of input, they believe that non-atmospheric boilers are more likely than atmospheric to run in the field at an excess air level above (and efficiency below) that at which the AFUE was measured, which is exactly opposite what is done in DOE's adjustment. (Crown, No. 30 at p. 9; U.S. Boiler, No. 31 at p. 9)

In response, DOE assumed that boilers at high fire operate at 15 to 20 percent excess air, based on an article in the ASHRAE Journal[70] and the relationship between excess air, stack temperature, and combustion efficiency from the Engineering Toolbox.[71] Based on these two sources, DOE made the following assumptions. For natural draft (atmospheric) boilers below 86 percent AFUE, DOE assumed 20 percent excess air and 400°F stack temperature, resulting in a triangular distribution of AFUE impact from 0 percent to 1.6 percent (0.8 percent average). For non-condensing mechanical draft boilers and natural draft boilers above 86-percent AFUE, DOE assumed 15 percent excess air and 400°F stack temperature, resulting in a 0.4 percent average, which is half of the impact on AFUE compared to natural draft boilers below 86 percent AFUE. For condensing boilers, DOE assumed 15 percent excess air and 200°F stack temperature, resulting in 0.2 percent average, which is half of the impact on AFUE compared to non-condensing mechanical draft boilers. DOE has not found additional data or information to support changing its methodology.

DOE requests comments, information, and data showing the relationship between boiler efficiency and excess air during AFUE testing and in the field.

3. Water Heating Use

Consumer boilers are often used to provide hot water in addition to space heating. The most common means of doing so are through an indirect water heater, tankless coil,

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[70] Eoff, D., *Understanding Fuel Savings in the Boiler Room*, ASHRAE Journal (2008) 50(12): pp. 38–43.
[71] The Engineering Toolbox, *Combustion Efficiency and Excess Air* (Available at: *www.engineeringtoolbox.com/boiler-combustion-efficiency-d_271.html*) (Last accessed Jan. 3, 2023).

or as an integrated part of the boiler. This functionality's energy use is taken into account in the DOE test procedure for consumer boilers.

As mentioned previously, DOE does not account for other boiler uses such as snow melt systems, pool or spa heating, or steam or hot water production for commercial processes, since currently DOE does not have any information about the prevalence and energy use of such systems. DOE welcomes information and data on these additional system types and processes.

RECS 2015 and CBECS 2018 do not directly provide information about whether a boiler is used to provide hot water. For that to happen, DOE determined that it is a prerequisite for the households and buildings with (a) boiler(s) to report using the same fuel for both space and water heating. DOE also estimated the probability of consumer boilers used for water heating based on a 2015 AHRI contractor survey.[72] DOE determined that boilers are used for water heating in 50 percent of gas-fired hot water boiler installations, 5 percent of gas-fired steam boiler installations, 40 percent of oil-fired hot water boiler installations, and 5 percent of oil-fired steam boiler installations.

On this topic, Crown and U.S. Boiler stated that according to EPCA's definition of a "furnace," within which boilers are included, nothing is said about domestic water production, so DOE's authority to include the energy use in the cost-benefit analysis for a standard is questionable. Crown and U.S. Boiler also stated that DOE's residential boiler

[72] AHRI, Survey of Boiler Installation Contractors (2015), Usage of Boilers for Both Heat and Hot Water, pp. 10-11 (Available at: *www.regulations.gov/document/EERE-2012-BT-STD-0047-0066*) (Last accessed Jan. 3, 2023).

test method is not designed to measure this energy consumption (including idle losses) and that DOE's crude attempt to estimate it includes several questionable and arbitrary assumptions. (Crown, No. 30 at pp. 9-10; U.S. Boiler, No. 31 at pp. 9-10) In response, DOE notes that EPCA requires DOE to consider the savings in operating costs throughout the estimated average life of the covered product in the type (or class) compared to any increase in the price of, or in the initial charges for, or maintenance expenses of, the covered product that are likely to result from a standard. (42 U.S.C. 6295(o)(2)(B)(i)(II)) As there is no restriction on the type of energy-consuming service provided by a covered product, it is appropriate for DOE to include all such energy consumption and related costs associated with boiler operation, including those for domestic hot water supply. DOE believes that its energy use approach for estimating energy use for water heating and idle losses is reasonable, but welcomes any comments, methodology suggestions, and data to make further improvements to its energy use model.

Crown and U.S. Boiler also stated that DOE is likely overstating the use of water heating by assuming any boiler, other than an oil-fired steam boiler, is providing water heating if RECS 2015 or CBECS 2012 reports the use of "tankless water heating." (Crown, No. 30 at pp. 9-10; U.S. Boiler, No. 31 at p. 10) Overall, DOE has found that the fraction of boilers that are used for water heating in its sample matches the available contractor survey data compiled by AHRI in 2014 and 2022. For the sampling process, DOE assumed that for oil-fired boilers (both steam and hot water), if RECS 2015 or CBECS 2018 reports the use of "tankless water heating," then the boiler provides hot water. For gas-fired boilers, only a fraction of the reported “tankless water heating” is assumed to be provided by the boiler.

See appendix 7B of the NOPR TSD for more information about the energy use analysis.

F. Life-Cycle Cost and Payback Period Analysis

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

- The LCC is the total consumer expense of an appliance or product over the life of that product, consisting of total installed cost (manufacturer selling price, distribution chain markups, sales tax, and installation costs) plus operating costs (expenses for energy use, maintenance, and repair). To compute the operating costs, DOE discounts future operating costs to the time of purchase and sums them over the lifetime of the product.
- The PBP is the estimated amount of time (in years) it takes consumers to recover the increased purchase cost (including installation) of a more-efficient product through lower operating costs. DOE calculates the PBP by dividing the change in purchase cost at higher efficiency levels by the change in annual operating cost for the year that amended or new standards are assumed to take effect.

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

For each considered efficiency level in each product class, DOE calculated the LCC and PBP for a nationally representative set of housing units and commercial buildings. As stated previously, DOE developed household samples from RECS 2015 and CBECS 2018. For each sample household and commercial building, DOE determined the energy consumption for the consumer boilers and the appropriate energy price. By developing a representative sample of households and commercial buildings, the analysis captured the variability in energy consumption and energy prices associated with the use of consumer boilers.

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

The computer model DOE uses to calculate the LCC relies on a Monte Carlo simulation to incorporate uncertainty and variability into the analysis. The Monte Carlo simulations randomly sample input values from the probability distributions and consumer boiler user samples. For this rulemaking, the Monte Carlo approach is implemented in MS Excel together with the Crystal Ball™ add-on.[73] The model calculated the LCC for products at each efficiency level for 10,000 housing units and commercial buildings per simulation run. The analytical results include a distribution of 10,000 data points showing the range of LCC savings for a given efficiency level relative to the no-new-standards case efficiency distribution. In performing an iteration of the Monte Carlo simulation for a given consumer, product efficiency is chosen based on its probability. If the chosen product efficiency is greater than or equal to the efficiency of the standard level under consideration, the LCC calculation reveals that a consumer is not impacted by the standard level. By accounting for consumers who already purchase more-efficient products, DOE avoids overstating the potential benefits from increasing product efficiency.

DOE calculated the LCC and PBP for consumers of consumer boilers as if each were to purchase a new product in the expected year of required compliance with new or amended standards. New and amended standards would apply to consumer boilers manufactured 5 years after the date on which any new or amended standard is published. (42 U.S.C. 6295(m)(4)(A)(ii)) At this time, DOE estimates publication of a final rule in mid-2024. Therefore, for purposes of its analysis, DOE used 2030 as the first full year of compliance with any amended standards for consumer boilers.

[73] Crystal Ball™ is commercially-available software tool to facilitate the creation of these types of models by generating probability distributions and summarizing results within Excel (Available at: *www.oracle.com/technetwork/middleware/crystalball/overview/index.html)* (Last accessed Jan. 3, 2023).

Table IV.9 summarizes the approach and data DOE used to derive inputs to the LCC and PBP calculations. The subsections that follow provide further discussion. Details of the spreadsheet model, and of all the inputs to the LCC and PBP analyses, are contained in chapter 8 of the NOPR TSD and its appendices.

Table IV.9 Summary of Inputs and Methods for the LCC and PBP Analysis*

Inputs	Source/Method
Product Cost	Derived by multiplying MPCs by manufacturer and retailer markups and sales tax, as appropriate. Used historical data to derive a price scaling index to project product costs.
Installation Costs	Baseline installation cost determined with data from RSMeans 2023. Assumed no change with efficiency level.
Annual Energy Use	The total annual energy use multiplied by the hours per year. Average number of hours based on field data. Variability: Based on RECS 2015 and CBECS 2018.
Energy Prices	*Natural Gas*: Based on EIA's Natural Gas Navigator data for 2022 and RECS 2015 billing data; *Electricity*: Based on EIA's Form 861 data for 2022 and RECS 2015 billing data; *Propane and Fuel Oil*: Based on EIA's State Energy Data System (SEDS) for 2021. *Variability*: Energy prices by States were used for residential and commercial applications. Marginal prices used for natural gas, propane, and electricity prices.
Energy Price Trends	Based on *AEO2023* price projections.
Repair and Maintenance Costs	Based on RSMeans data and other sources.
Product Lifetime	GHW: 26.9 years; GST: 23.7 years; OHW: 25.6 years; OST: 19.6 years.
Discount Rates	*Residential*: approach involves identifying all possible debt or asset classes that might be used to purchase the considered appliances, or might be affected indirectly. Primary data source was the Federal Reserve Board's Survey of Consumer Finances. *Commercial*: Calculated as the weighted-average cost of capital for businesses purchasing consumer boilers. Primary data source was Damodaran Online.
Compliance Date	2030

* References for the data sources mentioned in this table are provided in the sections following the table or in chapter 8 of the NOPR TSD.

1. Product Cost

To calculate consumer product costs, DOE multiplied the MPCs developed in the engineering analysis by the markups described previously (along with sales taxes). DOE used different markups for baseline products and higher-efficiency products, because

DOE applies an incremental markup to the increase in MSP associated with higher-efficiency products.

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

In the experience curve method, the real cost of production is related to the cumulative production or "experience" with a manufactured product. This experience is usually measured in terms of cumulative production. As experience (production) accumulates, the cost of producing the next unit decreases. The percentage reduction in cost that occurs with each doubling of cumulative production is known as the learning rate. In typical experience curve formulations, the learning rate parameter is derived using two historical data series: cumulative production and price (or cost). DOE obtained historical PPI data for heating equipment from 1999 to 2021 for cast iron boilers and from 1980 to 1986 and 1994 to 2014 for steel boilers from the Bureau of Labor Statistics (BLS).[74] The PPI data reflect nominal prices, adjusted for product quality changes. An inflation-adjusted (deflated) price index for heating equipment manufacturing was calculated by dividing the PPI series by the implicit price deflator for Gross Domestic Product Chained Price Index.[75]

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[74] See *www.bls.gov/ppi/*.
[75] See *www.bea.gov/data/gdp/gross-domestic-product*.

From 1999 to 2001, the deflated price index of the cast iron heating boiler was decreasing. Since then, the indices for cast iron boilers and steel boilers have both risen, due to rising prices of the raw materials. However, given the uncertainty in the material prices and the economy, it is uncertain the current trend of the price indices will be sustained. Therefore, DOE decided to use constant prices as the default price assumption to project future consumer boiler prices. Thus, projected prices for the LCC and PBP analysis are equal to the 2021 values for each efficiency level in each product class.

DOE requests comments on the default constant price trend for consumer boilers. DOE seeks comments on how material prices and technological advancement would be expected to impact future prices of consumer boilers.

2. Installation Cost

Installation cost includes labor, overhead, and any miscellaneous materials and parts needed to install the product, such as venting and piping modifications and condensate disposal that might be required when installing products at various efficiency levels. DOE estimated the costs associated with installing a boiler in a new housing unit/commercial building or as a replacement for an existing boiler. DOE used data from RSMeans to estimate the baseline and higher efficiency installation costs for consumer boilers.[76]

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[76] See *www.rsmeansonline.com/*.

DOE calculated the basic installation cost, which is applicable to both replacement and new construction boiler installations and includes the cost of putting in place and setting up the boiler, permitting, and removal or disposal fees. DOE also considered additional costs ("adders") for a fraction of installations of non-condensing and condensing boilers. These additional costs may account for installing a new vent system, chimney relining, updating of flue vent connectors, vent resizing, the costs for a stainless-steel vent, and condensate withdrawal (if required). In addition, DOE accounted for the costs associated with adding water heating service using the boiler (for example, through an indirect tank or through combination space heating/water heating boilers) for a fraction of installations. See chapter 8 and appendix 8C of the TSD for more details on installation cost including average installation costs by product class and efficiency level.

AHRI expressed concerns that RSMeans does not have enough resolution with respect to the differences in installation times for condensing and non-condensing boilers. (AHRI, No. 40 at p.6) WMT stated that RSMeans should not be utilized as a true job costing calculator because it does not accurately capture the true and nuanced costs of installation work. WMT believes the RSMeans data is intended as an initial estimation tool, providing information for businesses to benchmark against the larger industry and to provide quotations of complicated projects, and, in fact, RSMeans itself states that they have no expressed or implied warranty as to the fitness of the information for a particular purpose. WMT believes the actual cost of a project is determined after the work is completed, and, therefore, the best source of information for the difference in installation activities is the manufacturer's service call information. (WMT, No. 32 at pp. 10-11)

In response, DOE notes that the Department does not utilize RSMeans as the sole source for its estimation of boiler installation costs. DOE uses RSMeans data to provide labor costs, materials costs, and labor hours for a variety of installation tasks associated with installing a boiler. In order to appropriately characterize the installation costs, DOE used a variety of additional sources including consultant reports, manufacturer installation manuals, and other online resources. The resulting installation cost model for consumer boilers provides a distribution of costs that matches with available field data from 2014 and 2022 AHRI contractor surveys and other online resources (see Appendix 8D for more details).

Crown and U.S. Boiler argued that DOE used labor rates from RSMeans that do not appear applicable to residential boiler installation, service, and maintenance. Crown and U.S. Boiler stated that, for example, installation work on simple gas-fired natural draft non-condensing boilers is sometimes performed by plumbers. (Crown, No. 30 at p. 11; U.S. Boiler, No. 31 at p. 10) In response, DOE uses RSMeans data and consultant reports to estimate the appropriate labor crew for residential boiler tasks. DOE is aware that residential consumer boiler installations can be, and in certain cases are, accomplished by plumbers and other contractors, but RSMeans crew type for boilers approximates the average labor costs per hour for a crew performing the main boiler installation tasks. Also, the cost differential for this crew type versus a plumber for example is not very significant. (See appendix 8D of the NOPR TSD). Therefore, DOE kept its approach for using labor rates based on RSMeans for the NOPR analysis.

Crown and U.S. Boiler stated DOE is underestimating the relative difference in the installation costs for condensing and non-condensing boilers, and past discussions with their customers suggest that a $3500 adder for a condensing boiler installation, as evidenced by DOE's consultant, is closer to reality. (Crown, No. 30 at p. 11; U.S. Boiler, No. 31 at p. 11) In contrast, NEAA and the Joint Advocates stated that DOE's analysis of installation costs for consumer boilers is comprehensive and reasonable for condensing boiler installations and includes an evaluation of the installation issues associated with switching from a non-condensing to a condensing boiler. (NEAA, No. 36 at p. 2; Joint Advocates, No. 35 at p. 3) NYSERDA stated that DOE correctly found that new technologies have entered the market to help alleviate previously challenging installations, particularly related to venting, for condensing products. NYSERDA further commented that the contractors have significant experience installing these products in a wide variety of scenarios, as almost 40 percent of all furnaces and boilers in New York achieve a condensing level of performance. NYSERDA added that DOE's analysis, which revealed that fewer than 5 percent of installations could be labeled as challenging, is well-supported and reflects the significant gain of market share that condensing products have achieved over the last twenty years. (NYSERDA, No. 33 at p.3)

In response, DOE acknowledges that a small fraction of replacement installations may be difficult, but DOE does not believe that the difficulties are insurmountable. DOE notes that in response to the NOPR for the current residential furnaces rulemaking, the American Council for an Energy-Efficient Economy (ACEEE) stated that the Energy Coordinating Agency, a major weatherization program in Philadelphia that has installed many condensing furnaces in row houses, has developed moderate cost solutions (at most

$350) to common problems such as having no place to horizontally vent directly from the basement. (Docket No. EERE-2014-BT-STD-0031, ACEEE, No. 113 at p. 7) DOE's analysis accounts for additional costs for that small fraction of installations that would require significant installation costs in the range of several thousand dollars. DOE also accounts for adders for condensing models in a distribution of costs that matches with available field data from 2014 and 2022 AHRI contractor surveys and other online resources (see appendix 8D of the NOPR TSD for more details). Although in some areas and certain applications a bigger relative difference can be observed in the field, DOE argues that the distribution of costs it develops for the installation cost analysis will better represent field applications overall. DOE agrees with NYSERDA that the fraction of remaining difficult installations has been decreasing as the market share of condensing boiler installations has increased over time.

PB Heat stated that the current minimum efficiency levels for Category I, chimney-vented boilers are near physical limits of chimney venting. The commenter added that increasing boiler minimum efficiency levels beyond the current levels would significantly reduce the applications where a Category I boiler could be installed with an existing chimney and produce reliable and safe operation over its expected life. PB Heat asserted that increasing the minimum efficiency would reduce the flue temperature, which along with chimney height is a key driver for venting of flue gases, and this would increase the likelihood of condensation in the chimney (causing premature degradation) and the likelihood of poor draft, which can result in flue gas spillage into the heated space. (PB Heat, No. 34 at p. 1)

In response, DOE agrees that Category I venting may no longer be suitable for amended energy conservation standards set at significantly higher levels of boiler efficiency. DOE has estimated that in cases of replacement with near-condensing gas-fired boilers (85-89 percent AFUE), instead of using Category I chimney venting or Category II stainless steel venting, installers would use Category III stainless steel venting with mechanical draft.[77] When considering condensing boilers, Category I or Category II venting presents reliability issues, even with stainless steel venting, because of the variety of operating conditions encountered in the field. Accordingly, for this analysis, DOE assumed that for such installations (that otherwise would require Category II venting), it would be appropriate to install a mechanical draft boiler with Category III venting (which requires stainless steel venting), in order to prevent safety and reliability issues. DOE included the cost of AL29-4C stainless steel venting for all Category III installations.

AHRI stated that its contractor survey showed that while direct venting is a common means to vent condensing boilers, it is not the only method being used in the field. The commenter opined that the choice in venting is most likely based on the availability of the product and, as such, must be maintained as an option to ensure that contractors can install and vent boilers safely and effectively in all situations that they may encounter. (AHRI, No. 42 at p. 8) In response, for the preliminary analysis, DOE assumed that direct venting is used by a fraction of condensing installations. For the

[77] For replacement with an 84-percent AFUE boiler, DOE found that that it is necessary to use special venting in a small fraction of cases based on shipments data provided by Burnham during the 2015 NOPR. [EERE–2012–BT–STD–0047 (Burnham, No. 60, p.18)]

NOPR analysis, DOE updated its fraction of direct vent installations to match the data provided by AHRI's contractor survey.

AHRI stated that DOE is not including in its costing model the cost of replacement baseboard. AHRI elaborated that when a consumer switches from a non-condensing boiler to a condensing boiler, they will need to replace or increase the length of their baseboard to work with lower water temperatures in order to realize the energy savings potential of the condensing boiler. (AHRI, No. 40 at p. 1) AHRI's 2022 contractor survey shows that upgrading the heat emitter rarely occurs in practice. Therefore, for this analysis, DOE has chosen not to include the cost of replacing or increasing the length of the baseboard for retrofitting an existing non-condensing boiler with a condensing boiler. Instead, DOE has chosen to adjust the energy efficiency of the boiler to compensate for the decrease in the field efficiency of condensing boilers when the heat emitter is not sized properly.

3. Annual Energy Consumption

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

Higher-efficiency boilers reduce the operating costs for a consumer, which can lead to greater use of the boiler (*i.e.*, a "rebound effect"). A direct rebound effect occurs when a product that is made more efficient is used more intensively, such that the expected energy savings from the efficiency improvement may not fully materialize. At the same time, consumers benefit from increased utilization of products due to rebound. Although some households may increase their boiler use in response to increased efficiency, DOE does not include the rebound effect in the LCC analysis because the increased utilization of the water heater provides value to the consumer. DOE does include rebound in the NIA for a conservative estimate of national energy savings and the corresponding impact to consumer NPV. See section IV.H.3 of this document and chapter 10 of the NOPR TSD for more details.

4. Energy Prices

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

DOE derived average monthly marginal residential and commercial electricity, natural gas, LPG, and fuel oil prices for each State using data from EIA.[78,79,80] DOE calculated marginal monthly regional energy prices by: (1) first estimating an average annual price for each region; (2) multiplying by monthly energy price factors, and (3)

[78] U.S. Department of Energy-Energy Information Administration, Form EIA-861M (formerly EIA-826) detailed data (2022) (Available at*: www.eia.gov/electricity/data/eia861m/*) (Last accessed May 3, 2023).
[79] U.S. Department of Energy-Energy Information Administration, Natural Gas Navigator (2022) (Available at: *www.eia.gov/naturalgas/data.php*) (Last accessed May 3, 2023).
[80] U.S. Department of Energy-Energy Information Administration, 2021 State Energy Data System (SEDS) (2021) (Available at: *www.eia.gov/state/seds/*) (Last accessed May 3, 2023).

multiplying by seasonal marginal price factors for electricity, natural gas, LPG, and fuel oil. The analysis used historical data up to 2022 for residential and commercial natural gas and electricity prices and historical data up to 2021 for LPG and fuel oil prices adjusted to 2022 values using *AEO* data. Further details may be found in chapter 8 of the NOPR TSD.

The Joint Commenters encouraged DOE to evaluate one or more alternate natural gas price scenarios to better understand the effect of increased gas prices, because they believe that DOE significantly underestimates future natural gas prices using the projections from *AEO 2021*. The Joint Commenters argued that as the movement towards electrification continues and the efficiencies of gas-fired appliances increase, customers and sales of natural gas will likely decline over time and that multiple studies indicate that a consistent decline in gas customers and/or consumption will result in an increase in gas prices for the remaining customers. (Joint Commenters, No. 35 at p. 2)

In response, because the extent of widespread electrification, and the associated impact on natural gas prices, are very uncertain at this point, DOE prefers to rely on the latest *AEO* price forecasts in its analysis. DOE uses other inputs from the *AEO* analysis, and the Department contends that it is important to maintain consistency in terms of its use of *AEO* in DOE's other inputs and energy price projections since they are interconnected in the National Energy Modeling System (NEMS) that EIA uses.[81] DOE notes that if future natural gas prices end up higher than DOE estimates due to

[81] See *www.eia.gov/outlooks/aeo/info_nems_archive.php*.

electrification, the economic justification for the standards proposed for gas-fired boilers in this NOPR would become stronger still. DOE's analysis also includes sensitivity analysis using energy prices in high and low economic growth scenarios. However, DOE has tentatively concluded that such alternate energy price trends are too speculative for use as the agency's primary analysis.

Accordingly, for this NOPR, to estimate energy prices in future years, DOE multiplied the 2022 energy prices by the projection of annual average price changes for each of the nine Census Divisions from the Reference case in *AEO 2023*, which has an end year of 2050. [82] To estimate price trends after 2050, DOE used the average annual growth rate in prices from 2046 to 2050 based on the methods used in the 2022 Life-Cycle Costing Manual for the Federal Energy Management Program (FEMP).[83]

5. Maintenance and Repair Costs

Repair costs are associated with repairing or replacing product components that have failed in an appliance; maintenance costs are associated with maintaining the operation of the product. Typically, small incremental increases in product efficiency produce no, or only minor, changes in repair and maintenance costs compared to baseline efficiency products. In the present case, DOE included additional repair costs for higher-efficiency consumer boilers (including repair costs associated with electronic ignition,

[82] EIA. *Annual Energy Outlook 2023 with Projections to 2050*. Washington, DC (Available at: *www.eia.gov/forecasts/aeo/*) (Last accessed May 3, 2023).
[83] Lavappa, Priya D. and J. D. Kneifel, Energy Price Indices and Discount Factors for Life-Cycle Cost Analysis – 2022 Annual Supplement to NIST Handbook 135. National Institute of Standards and Technology (NIST). NISTIR 85-3273-37 (Available at: *www.nist.gov/publications/energy-price-indices-and-discount-factors-life-cycle-cost-analysis-2022-annual*) (Last accessed Jan. 3, 2023).

controls, and blowers for condensing designs) based on 2023 RSMeans data. DOE also accounted for regional differences in labor costs by using RSMeans regional cost factors. Further details may be found in appendix 8F of the NOPR TSD.

Crown and U.S. Boiler stated that DOE used labor rates from RSMeans that do not appear applicable to residential boiler service and maintenance. Crown and U.S. Boiler stated that maintenance and repair on residential boilers mostly will be performed by an HVAC technician, which requires a completely different skill set from the "steam fitter and steam fitter apprentice" that DOE assumed. (Crown, No. 30 at p. 11; U.S. Boiler, No. 31 at p. 10)

In response, DOE uses RSMeans data and consultant reports to estimate the appropriate labor crew for residential boiler tasks. DOE is aware that residential consumer boiler maintenance and repair are typically accomplished by an HVAC technician, but the RSMeans crew type for boilers approximates the average labor costs per hour for a crew performing these maintenance and repair tasks. See IV.F.2 of this document for further discussions about the use of RSMeans. Therefore, DOE kept its approach for using labor rates from RSMeans.

6. Product Lifetime

Product lifetime is the age at which an appliance is retired from service. To determine boiler lifetimes, DOE relied on RECS 1990, 1993, 2001, 2005, 2009, 2015, and 2020. DOE also used the U.S. Census's biennial American Housing Survey (AHS), from 1974-2021, which surveys all housing and notes the presence of a range of appliances. DOE used the appliance age data from these surveys, as well as the historical boiler shipments, to generate an estimate of the survival function for consumer boilers. The survival function provides a lifetime range from minimum to maximum, as well as an average lifetime.

PB Heat and AHRI stated that condensing boilers have a shorter lifespan than non-condensing boilers, in line with AHRI's Survey of Boiler Installation Contractors (July 2015) and EER Consultants on boiler lifetime. (PB Heat, No. 34 at p. 1; AHRI, No. 40 at p. 5) AHRI stated that the contractor survey it conducted showed that condensing boilers on average are expected to last between 10-20 years. (AHRI, No. 42 at p. 6) BWC commented that condensing boilers are technically more complex products with additional components, and that they have higher lifetime service and maintenance costs compared to non-condensing boilers, which are contributing factors that make it challenging for condensing boilers to have the same life span as non-condensing boilers. (BWC, No. 39 at p. 2) PB Heat mentioned the complexity of condensing boilers and negatively impacting their lifetime, and the company stated that the heat exchanger of a boiler is the key component whose failure is highly likely to drive early end-of-life decisions. (PB Heat, No. 34 at p. 2) Crown and U.S. Boilers stated that condensing boilers have a significantly shorter life expectancy than non-condensing boilers because of their increased complexity, exposure of components to acids, and also the much tighter flue and water passages that are subject to fouling if not cleaned diligently. Crown and U.S. Boilers pointed to the difference in the heat exchanger warranty coverages as an indication of what manufacturers themselves expect the lifetime to be. (Crown, No. 30 at p. 11-15; U.S. Boilers, No. 31 at pp. 12-16) WMT stated that the product lives of condensing boilers are approximately half that of the 25- to 30-year expected life of cast iron non-condensing boilers. (WMT, No. 32 at pp. 2-3) Crown and U.S. Boilers also stated that many of DOE's sources are even older than the 2016 AHRI survey whose values DOE did not adopt. (Crown, No. 30 at p. 12; U.S. Boilers, No. 31 at p. 12)

After carefully considering these comments, DOE has concluded that there is not enough data available to accurately distinguish the lifetime of non-condensing and condensing gas-fired boilers, because they have not been prevalent in the U.S. market long enough to demonstrate whether their average lifetime is less than or greater than 25 years. Commenters provided opinions based on their conjecture and certain anecdotal experiences, but they did not provide data that would evidence a significantly reduced lifetime for condensing boilers. In addition, condensing boiler technologies have been improving since their introduction to the U.S. market; therefore, the lifetime of the earliest condensing boilers may not be representative of current or future condensing boiler designs. Consequently, condensing lifetime estimates from AHRI's contractor survey might be biased towards earliest condensing boiler designs, and it lacks clarity as to the number of condensing boilers installed that were 15 years or older. Therefore, DOE has maintained the same lifetime for condensing and non-condensing boilers for this NOPR. However, as mentioned previously, DOE did include additional repair costs for condensing boilers that would likely allow for a lifetime similar to non-condensing boilers, by assuming different service lifetimes for heat exchangers for condensing boilers and non-condensing boilers based on warranty data from product literature and survey data provided by stakeholders.

In light of the above, for this NOPR, DOE used the appliance age data derived from RECS 1990-2020 and the U.S. Census's biennial American Housing Survey (AHS) 1974-2021, as well as the historical boiler shipments, to generate an estimate of the survival function for consumer boilers. The survival function provides a lifetime range from minimum to maximum, as well as an average lifetime. Utilizing this approach, DOE estimates the average product lifetime to be 24.6 years for consumer boilers. This estimate is consistent with the range of values identified in a literature review in appendix 8G of the NOPR TSD.

7. Discount Rates

In the calculation of LCC, DOE applies discount rates appropriate to households and commercial buildings to estimate the present value of future operating cost savings. DOE estimated a distribution of discount rates for consumer boilers based on the opportunity cost of consumer funds and cost of capital for commercial applications.

DOE applies weighted-average discount rates calculated from consumer debt and asset data, rather than marginal or implicit discount rates.[84] The LCC analysis estimates net present value over the lifetime of the product, so the appropriate discount rate will reflect the general opportunity cost of household funds, taking this time scale into account. Given the long time horizon modeled in the LCC analysis, the application of a

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[84] 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; and interest rates at which a consumer is able to borrow or lend. The implicit discount rate is not appropriate for the LCC analysis because it reflects a range of factors that influence consumer purchase decisions, rather than the opportunity cost of the funds that are used in purchases.

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 applications, DOE's method views the purchase of a higher-efficiency appliance as an investment that yields a stream of energy cost savings. DOE derived the discount rates for the LCC analysis by estimating the cost of capital for companies or public entities that purchase consumer boilers. For private firms, the weighted-average cost of capital (WACC) is commonly used to estimate the present value of cash flows to be derived from a typical company project or investment. Most companies use both debt and equity capital to fund investments, so their cost of capital is the weighted average of the cost to the firm of equity and debt financing, as estimated from financial data for publicly-traded firms in the sectors that purchase consumer boilers. As discount rates can differ across industries, DOE estimates separate discount rate distributions for a number of aggregate sectors with which elements of the LCC building sample can be associated.

To establish residential discount rates for the LCC analysis, DOE identified all relevant household debt or asset classes in order to approximate a consumer's opportunity cost of funds related to appliance energy cost savings. It estimated the average percentage shares of the various types of debt and equity by household income group using data from the Federal Reserve Board's triennial Survey of Consumer Finances[85] (SCF) starting in 1995 and ending in 2019. Using the SCF and other sources, DOE developed a distribution of rates for each type of debt and asset by income group to represent the rates that may apply in the year in which amended standards would take effect. DOE assigned each sample household a specific discount rate drawn from one of the distributions. The average rate across all types of household debt and equity and income groups, weighted by the shares of each type, is 4.2 percent.

To establish commercial discount rates for the small fraction of consumer boilers installed in commercial buildings, DOE estimated the weighted-average cost of capital using data from Damodaran Online.[86] The weighted-average cost of capital is commonly used to estimate the present value of cash flows to be derived from a typical company project or investment. Most companies use both debt and equity capital to fund investments, so their cost of capital is the weighted average of the cost to the firm of equity and debt financing. DOE estimated the cost of equity using the capital asset pricing model, which assumes that the cost of equity for a particular company is proportional to the systematic risk faced by that company. DOE's commercial discount rate approach is based on the methodology described in an LBNL report, and the distribution varies by business activity.[87] The average rate for consumer boilers used in

[85] The Federal Reserve Board, Survey of Consumer Finances (1995, 1998, 2001, 2004, 2007, 2010, 2013, 2016, and 2019) (Available at: *www.federalreserve.gov/econres/scfindex.htm*) (Last accessed Jan. 3, 2023).
[86] Damodaran Online, Data Page: Costs of Capital by Industry Sector (2022) (Available at: *pages.stern.nyu.edu/~adamodar/*) (Last accessed May 3, 2023).
[87] Fujita, K. Sydny. Commercial, Industrial, and Institutional Discount Rate Estimation for Efficiency Standards Analysis: Sector-Level Data 1998 – 2022. 2023. (Available at: eta-publications.lbl.gov/publications/commercial-industrial-and-2) (Last accessed May 3, 2023).

commercial applications in this NOPR analysis, across all business activity, is 10.0 percent.

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

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

To accurately estimate the share of consumers that would be affected by a potential energy conservation standard at a particular efficiency level, DOE's LCC analysis considered the projected distribution (market shares) of product efficiencies under the no-new-standards case (*i.e.*, the case without amended or new energy conservation standards) in the compliance year (2030). This approach reflects the fact that some consumers may purchase products with efficiencies greater than the baseline levels.

To estimate the energy efficiency distribution of consumer boilers for 2030, DOE used available shipments data by efficiency, including previous AHRI-submitted historical shipments data, ENERGY STAR unit shipments data, 2013-2021 HARDI shipment data, and data from the 2022 BRG Building Solutions report. To cover gaps in the available shipments data, DOE used DOE's public CCD model database and AHRI certification directory.

In its comments on the May 2022 Preliminary Analysis, AHRI submitted 2021 shipment data for gas-fired hot water boilers to DOE. AHRI stated that while there is an array of products at 85-percent AFUE in the AHRI Directory and CCD, these products do not account for a significant portion of current shipments. (AHRI, No. 42 at p. 2) For the NOPR, DOE included these data to supplement its fraction of 85-percent AFUE gas-fired hot water consumer boilers.

The estimated market shares for the no-new-standards case for consumer boilers are shown in Table IV.10.

Table IV.10 No-New-Standards Case Energy Efficiency Distributions in 2030 for Consumer Boilers

Product Class	Efficiency Level	Distribution
Gas-fired Hot Water	0	13.3%
	1	2.5%
	2	10.7%
	3	45.4%
	4	7.6%
Gas-fired Steam	0	7.6%
	1	1.6%
Oil-fired Hot Water	0	7.5%
	1	1.9%
	2	1.0%
Oil-fired Steam	0	0.8%
	1	0.1%

Each building in the sample was then assigned a boiler efficiency sampled from the no-new-standards-case efficiency distribution for the appropriate product class shown in Table IV.10. In assigning boiler efficiencies, DOE determined that, based on the presence of well-understood market failures (discussed at the end of this section), a random assignment of efficiencies, with some modifications discussed below, best accounts for consumer behavior in the consumer boilers market. Random assignment of efficiencies reflects the full range of consumer behaviors in this market, including consumers who make economically beneficial decisions and consumers that, due to market failures, do not make such economically beneficial decisions.

The LCC Monte Carlo simulations draw from the efficiency distributions and randomly assign an efficiency to the consumer boilers purchased by each sample household and commercial building in the no-new-standards case. The resulting percentage shares within the sample match the market shares in the efficiency distributions. But, as mentioned previously, DOE considered available data in determining whether any modifications should be made to the random assignment methodology. First, DOE considered the 2022 AHCS survey,[88] which includes questions to recent purchasers of HVAC equipment regarding the perceived efficiency of their equipment (Standard, High, and Super-High Efficiency), as well as questions related to various household and demographic characteristics. From these data, DOE found that households with larger square footage exhibited a higher fraction of High or Super-High efficiency equipment installed. DOE used the AHCS data to adjust the efficiency distributions as follows: (1) the market share of higher-efficiency equipment for households under 1,500 sq. ft. was decreased by 5 percentage points; and (2) the market share of condensing equipment for households above 2,500 sq. ft. was increased by 5 percentage points.

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[88] Decision Analysts, 2022 American Home Comfort Studies (Available at: *www.decisionanalyst.com/Syndicated/HomeComfort/*) (Last accessed Jan. 3, 2023).

AHRI stated that, based on contractor survey data submitted with its comment, a condensing boiler is nearly twice as likely to be chosen over a non-condensing model in new construction. (AHRI, No. 42 at p. 3) In response, DOE notes that for the preliminary analysis, DOE already assigned a greater fraction of condensing boilers to the new construction market. However, for the NOPR, DOE increased its fraction of condensing boilers assigned to the new construction market further to match the data provided in the 2022 AHRI contractor survey.

AGA, APGA, and NPGA stated that DOE should place greater emphasis on providing an argument for the plausibility and magnitude of any market failure related to the energy efficiency gap in its analyses. These commenters added that for some commercial goods in particular, there should be a presumption that market actors behave rationally, unless DOE can provide evidence or argument to the contrary. (AGA, APGA, and NPGA, No. 38 at p. 4)

In contrast to the preceding comments, NYSERDA stated that DOE's assignment of boiler efficiency in the no-new-standards case, using State-level market data in conjunction with the 2015 RECS and the 2019 American Home Comfort Study, is thorough and robust and that DOE has appropriately used its wide discretion in this matter to conduct a reasonable and rigorous analysis of consumer purchasing decisions. (NYSERDA, No. 33 at p. 3) The Joint Commenters also expressed the view that DOE's assignment of efficiency levels in the no-new-standards case reasonably reflects actual consumer behavior and that the Department's assignment of boiler efficiency in the no-new-standards case is not entirely random. Specifically, the Joint

Commenters stated that DOE used State-level market data to preferentially assign higher-efficiency boilers to States with higher fractions of high-efficiency boiler shipments, and within each State, DOE used the 2015 RECS and the 2019 American Home Comfort Study to account for subgroups that could select higher-efficiency boilers more often, such as homes with higher square footage. Further, the Joint Commenters pointed out that there are various market failures, as well as aspects of consumer preference, that significantly impact how products are chosen by consumers, and there are often misaligned incentives in rental properties, where the landlord purchases and installs the boiler while the renter is responsible for paying the utility bill. Additionally, the Joint Commenters stated that information about the purchase price, installation cost, and projected energy costs of boilers is not always transparent, so consumers are likely to make decisions that do not result in the highest net present value for their specific scenario. (Joint Commenters, No. 35 at p. 3)

In response, for this NOPR, DOE continued to assign boiler efficiency to households in the no-new-standards case in two steps, first at the State level and then at the building-specific level. However, DOE's approach was modified to include other household characteristics. The market share of each efficiency level at the State level is based on historical shipments data (from the 2012 AHRI and 2013-2021 HARDI data) and to assign the efficiency at the building-specific level, DOE carefully considered any available data that might improve assignment of boiler efficiency in the LCC analysis. First, DOE examined the 2013-2021 HARDI data of gas boiler input capacity by efficiency level and region. DOE did not find a significant correlation between input capacity and condensing boiler market share in a given region, a correlation which might be expected *a priori* since buildings with larger boiler input capacity are more likely to be larger and have greater energy consumption. DOE next considered the Gas Technology Institute (GTI) data for 21 Illinois households, which included the efficiency of the boiler (AFUE), size of the boiler (input capacity), square footage of the house, and annual energy use.[89] Recognizing the relatively small sample size, DOE notes that these data exhibit no significant correlations between boiler efficiency and other household characteristics (with most boiler installations in this sample being non-condensing boilers with high energy use). DOE also considered other data of boiler efficiency compared to household characteristics for other parts of the country, including the NEEA Database and permit data.[90] These data also suggest fairly weak correlation between boiler efficiency and household characteristics or economic factors. Finally, DOE considered the 2022 AHCS survey data. From these data, DOE did find a statistically significant correlation: Households with larger square footage exhibited a higher fraction of High or Super-High efficiency equipment installed.

While DOE acknowledges that economic factors may play a role when consumers, commercial building owners, or builders decide on what type of boiler to install, assignment of boiler efficiency for a given installation, based solely on economic measures such as life-cycle cost or simple payback period, most likely would not fully and accurately reflect actual real-world installations. There are a number of market failures discussed in the economics literature that illustrate how purchasing decisions

[89] Gas Technology Institute (GTI), Empirical Analysis of Natural Gas Furnace Sizing and Operation, GTI-16/0003 (Nov. 2016) (Available at: *www.regulations.gov/document/EERE-2014-BT-STD-0031-0309*) (Last accessed Jan. 3, 2023).

[90] See *neea.org/data/residential-building-stock-assessment* (Last accessed Jan. 3, 2023).

with respect to energy efficiency are unlikely to be perfectly correlated with energy use, as described below. DOE maintains that the method of assignment, which is in part random, is a reasonable approach. It simulates behavior in the boiler market, where market failures result in purchasing decisions not being perfectly aligned with economic interests, and it does so more realistically than relying only on apparent cost-effectiveness criteria derived from the limited information in CBECS or RECS. DOE further emphasizes that its approach does not assume that all purchasers of boilers make economically irrational decisions (*i.e.*, the lack of a correlation is not the same as a negative correlation). As part of the random assignment, some homes or buildings with large heating loads will be assigned higher-efficiency boilers, and some homes or buildings with particularly low heating loads will be assigned baseline boilers, which aligns with the available data. By using this approach, DOE acknowledges the uncertainty inherent in the data and minimizes any bias in the analysis by using random assignment, as opposed to assuming certain market conditions that are unsupported by the available evidence.

The following discussion provides more detail about the various market failures that affect consumer boiler purchases. First, consumers are motivated by more than simple financial trade-offs. There are consumers who are willing to pay a premium for more energy-efficient products because they are environmentally conscious.[91] There are also several behavioral factors that can influence the purchasing decisions of complicated

[91] Ward, D. O., Clark, C. D., Jensen, K. L., Yen, S. T., & Russell, C. S. (2011): "Factors influencing willingness-to pay for the ENERGY STAR® label," *Energy Policy*, *39*(3), 1450-1458 (Available at: www.sciencedirect.com/science/article/abs/pii/S0301421510009171) (Last accessed Jan. 3, 2023).

multi-attribute products, such as boilers. For example, consumers (or decision makers in an organization) are highly influenced by choice architecture, defined as the framing of the decision, the surrounding circumstances of the purchase, the alternatives available, and how they are presented for any given choice scenario.[92] 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.[93] 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.[94] These characteristics describe almost all purchasing situations of appliances and equipment, including boilers. The installation of a new or replacement boiler is done very infrequently, as evidenced by the mean lifetime of 24.6 years for boilers. Additionally, it would take at least one full heating season for any impacts on operating costs to be fully apparent. Further, if the purchaser of the boiler is not the entity paying the energy costs (*e.g.,* a building owner and tenant), there may be little to no

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[92] Thaler, R.H., Sunstein, C.R., and Balz, J.P. (2014), "Choice Architecture" in *The Behavioral Foundations of Public Policy*, Eldar Shafir (ed).
[93] 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).
[94] Thaler, R.H., and Sunstein, C.R. (2008), Nudge: Improving Decisions on Health, Wealth, and Happiness. New Haven, CT: Yale University Press.

feedback on the purchase. Additionally, there are systematic market failures that are likely to contribute further complexity to how products are chosen by consumers, as explained in the following paragraphs.

The first of these market failures—the split-incentive or principal-agent problem—is likely to affect boilers more than many other types of appliances. The principal-agent problem is a market failure that results when the consumer that purchases the equipment does not internalize all of the costs associated with operating the equipment. Instead, the user of the product, who has no control over the purchase decision, pays the operating costs. There is a high likelihood of split-incentive problems in the case of rental properties where the landlord makes the choice of what boiler to install, whereas the renter is responsible for paying energy bills. In the LCC sample, about 30 percent of households with a boiler are renters. These fractions are significantly higher for low-income households (see section IV.I of this document). In new construction, builders influence the type of boiler used in many homes but do not pay operating costs. Finally, contractors install a large share of boilers in replacement situations, and they can exert a high degree of influence over the type of boiler purchased by suggesting certain designs or models for the replacement.

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

Additionally, Davis and Metcalf[95] conducted an experiment demonstrating that the nature of the information available to consumers from EnergyGuide labels posted on air conditioning equipment results in an inefficient allocation of energy efficiency across households with different usage levels. Their findings indicate that households are likely to make decisions regarding the efficiency of the climate-control equipment of their homes that do not result in the highest net present value for their specific usage pattern (*i.e.*, their decision is based on imperfect information and, therefore, is not necessarily optimal). Also, most consumers did not properly understand the labels (specifically whether energy consumption and cost estimates were national averages or specific to their State). As such, consumers did not make the most informed decisions.

In part because of the way information is presented, and in part because of the way consumers process information, there is also a market failure consisting of a systematic bias in the perception of equipment energy usage, which can affect consumer choices. Attari, Krantz, and Weber[96] show that consumers tend to underestimate the energy use of large energy-intensive appliances, but overestimate the energy use of small

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[95] Davis, L. W., and G. E. Metcalf (2016): “Does better information lead to better choices? Evidence from energy-efficiency labels,” Journal of the Association of Environmental and Resource Economists, 3(3), 589-625 (Available at: *www.journals.uchicago.edu/doi/full/10.1086/686252*) (Last accessed Jan. 3, 2023).
[96] Attari, S. Z., M.L. DeKay, C.I. Davidson, and W. Bruine de Bruin (2010): "Public perceptions of energy consumption and savings." Proceedings of the National Academy of Sciences 107(37), 16054-16059 (Available at: *www.pnas.org/content/107/37/16054*) (Last accessed Jan. 3, 2023).

appliances. Therefore, it is likely that consumers systematically underestimate the energy use associated with boilers, resulting in less cost-effective boiler purchases.

These market failures affect a sizeable share of the consumer population. A study by Houde[97] indicates that there is a significant subset of consumers that appear to purchase appliances without taking into account their energy efficiency and operating costs at all.

There are market failures relevant to boilers installed in commercial applications as well. It is often assumed that because commercial and industrial customers are businesses that have trained or experienced individuals making decisions regarding investments in cost-saving measures, some of the commonly observed market failures present in the general population of residential customers should not be as prevalent in a commercial setting. However, there are many characteristics of organizational structure and historic circumstance in commercial settings that can lead to underinvestment in energy efficiency.

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

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[97] Houde, S. (2018): "How Consumers Respond to Environmental Certification and the Value of Energy Information," The RAND Journal of Economics, 49 (2), 453-477 (Available at: *onlinelibrary.wiley.com/doi/full/10.1111/1756-2171.12231*) (Last accessed Jan. 3, 2023).

subsequent building owner) pays for energy costs.[98, 99] Indeed, more than a quarter of commercial buildings in the CBECS 2018 sample are occupied at least in part by a tenant, not the building owner (indicating that, in DOE's experience, the building owner 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 also impact the choice of a boiler. 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.[100] 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.[101] 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

[98] 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.

[99] 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 Jan. 3, 2023).

[100] 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).

[101] 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).

same organization, as well as information asymmetries between market actors in the energy efficiency context in commercial building construction.[102]

Second, the nature of the organizational structure and design can influence priorities for capital budgeting, resulting in choices that do not necessarily maximize profitability.[103] 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.[104] U.S. tax rules for commercial buildings may incentivize lower capital expenditures, since capital costs must be

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[102] 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 Jan. 3, 2023).

[103] 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.

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

depreciated over many years, whereas operating costs can be fully deducted from taxable income or passed through directly to building tenants.[105]

Third, there are asymmetric information and other potential market failures in financial markets in general, which can affect decisions by firms with regard to their choice among alternative investment options, with energy efficiency being one such option.[106] Asymmetric information in financial markets is particularly pronounced with regard to energy efficiency investments.[107] 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,[108] which can bias firms towards more certain or familiar options. This market failure results not because the returns from energy efficiency as an investment are inherently riskier, but because information about the risk itself tends not to be available in the same way it is for other types of investment,

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[105] Lovins, A. (1992), Energy-Efficient Buildings: Institutional Barriers and Opportunities (Available at: *rmi.org/insight/energy-efficient-buildings-institutional-barriers-and-opportunities/*) (Last accessed Jan. 3, 2023).

[106] 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.

[107] Mills, E., Kromer, S., Weiss, G., and Mathew, P. A. (2006). "From volatility to value: analysing and managing financial and performance risk in energy savings projects," *Energy Policy*, 34(2), 188-199.
Jollands, N., Waide, P., Ellis, M., Onoda, T., Laustsen, J., Tanaka, K., and Meier, A. (2010). "The 25 IEA energy efficiency policy recommendations to the G8 Gleneagles Plan of Action," *Energy Policy*, 38(11), 6409-6418.

[108] 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 Jan. 3, 2023).

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.[109] This information asymmetry extends to commercial investors, lenders, and real-estate financing, which is biased against new and perhaps unfamiliar technology (even though it may be economically beneficial).[110] 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.[111]

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[112] and required payback periods of many firms are higher than the

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[109] Cooremans, C. (2012). "Investment in energy efficiency: do the characteristics of investments matter?" *Energy Efficiency*, 5(4), 497-518.
[110] 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 Jan. 3, 2023).
[111] 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 Jan. 3, 2023).
[112] 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.

appropriate cost of capital for the investment.[113] 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.[114] The study found that multiple organizational and institutional factors caused firms to require shorter payback periods and higher returns than the cost of capital for alternative investments of similar risk. Another study demonstrated similar results with firms requiring very short payback periods of 1-2 years in order to adopt energy-saving projects, implying hurdle rates of 50 to 100 percent, despite the potential economic benefits.[115] 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,[116] supermarkets,[117] and the electric motor market.[118]

The existence of market failures in the residential and commercial sectors is well supported by the economics literature and by a number of case studies. If DOE

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[113] DeCanio 1994, op. cit.

[114] DeCanio, S. J. (1998). "The Efficiency Paradox: Bureaucratic and Organizational Barriers to Profitable Energy-Saving Investments," *Energy Policy*, 26(5), 441-454.

[115] 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.

[116] 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.

[117] 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.

[118] 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 Jan. 3, 2023).

developed an efficiency distribution that assigned boiler efficiency in the no-new-standards case solely according to energy use or economic considerations such as life-cycle cost or payback period, the resulting distribution of efficiencies within the building sample would not reflect any of the market failures or behavioral factors above. Thus, DOE concludes such a distribution would not be representative of the consumer boiler market. Further, even if a specific household/building/organization is not subject to the market failures above, the purchasing decision of boiler efficiency can be highly complex and influenced by a number of factors not captured by the building characteristics available in the RECS or CBECS samples. These factors can lead to households or building owners choosing a boiler efficiency that deviates from the efficiency predicted using only energy use or economic considerations such as life-cycle cost or payback period (as calculated using the information from RECS 2015 or CBECS 2018). However, DOE intends to investigate this issue further, and it welcomes suggestions as to how it might improve its assignment of boiler efficiency in its analyses.

See chapter 8 of the NOPR TSD for further information on the derivation of the efficiency distributions.

9. Payback Period Analysis

The payback period is the amount of time (expressed in years) it takes the consumer to recover the additional installed cost of more-efficient products, compared to baseline products, through energy cost savings. Payback periods that exceed the life of the product mean that the increased total installed cost is not recovered in reduced operating expenses.

The inputs to the PBP calculation for each efficiency level are the change in total installed cost of the product and the change in the first-year annual operating expenditures relative to the baseline. DOE refers to this as a "simple PBP" because it does not consider changes over time in operating cost savings. The PBP calculation uses the same inputs as the LCC analysis when deriving first-year operating costs.

As noted previously, EPCA establishes a rebuttable presumption that a standard is economically justified if the Secretary finds that the additional cost to the consumer of purchasing a product complying with an energy conservation standard level will be less than three times the value of the first year's energy savings resulting from the standard, as calculated under the applicable test procedure. (42 U.S.C. 6295(o)(2)(B)(iii)) For each considered efficiency level, DOE determined the value of the first year's energy savings by calculating the energy savings in accordance with the applicable DOE test procedure, and multiplying those savings by the average energy price projection for the year in which compliance with the amended standards would be required.

G. Shipments Analysis

DOE uses projections of annual product shipments to calculate the national impacts of potential amended or new energy conservation standards on energy use, NPV, and future manufacturer cash flows.[119] The shipments model takes an accounting approach, tracking market shares of each product class and the vintage of units in the stock. Stock accounting uses product shipments as inputs to estimate the age distribution

[119] 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.

of in-service product stocks for all years. The age distribution of in-service product stocks is a key input to calculations of both the NES and NPV, because operating costs for any year depend on the age distribution of the stock.

DOE developed shipment projections based on historical data and an analysis of key market drivers for each product. DOE estimated consumer boiler shipments by projecting shipments in three market segments: (1) replacement of existing consumer boilers; (2) new housing; and (3) new owners in buildings that did not previously have a consumer boiler or existing boiler owners that are adding an additional consumer boiler.[120]

To project boiler replacement shipments, DOE developed retirement functions from boiler lifetime estimates and applied them to the existing products in the housing stock, which are tracked by vintage. DOE calculated replacement shipments using historical shipments and the lifetime estimates. Annual historical shipments sources are: (1) Appliance Magazine;[121] (2) multiple AHRI data submittals (2003-2012); (3) BRG Building Solutions 2022 report; (4) ENERGY STAR unit shipments data;[122] (5) 2013-2021 HARDI shipments; and (6) the 2016 Consumer Boiler Final Rule. In addition,

[120] The new owners primarily consist of households that add or switch to a different space heating option during a major remodel. Because DOE calculates new owners as the residual between its shipments model compared to historical shipments, new owners also include shipments that switch away from boiler product class to another.

[121] Appliance Magazine. *Appliance Historical Statistical Review: 1954-2012*. 2014. UBM Canon.

[122] ENERGY STAR, Unit Shipments data 2010-2021. multiple reports (Available at: *www.energystar.gov/partner_resources/products_partner_resources/brand_owner_resources/unit_shipment_data*) (Last accessed Jan. 3, 2023).

DOE adjusted replacement shipments by taking into account demolitions, using the estimated changes to the housing stock from *AEO 2023*.

To project shipments to the new housing market, DOE used the *AEO 2023* housing starts and commercial building floor space projections to estimate future numbers of new homes and commercial building floor space. DOE then used data from U.S. Census Characteristics of New Housing, [123,124] Home Innovation Research Labs Annual Builder Practices Survey,[125] RECS 2020 housing characteristics data, AHS 2021, and CBECS 2018 building characteristics data to estimate new construction boiler saturations by consumer boiler product class.

DOE estimated shipments to the new owners market based on the residual shipments from the calculated replacement and new construction shipments compared to historical shipments in the last five years (2017-2021 for this NOPR). DOE compared this with data from Decision Analysts' 2002 to 2022 American Home Comfort Study[126] and 2022 BRG data, which showed similar historical fractions of new owners. DOE assumed that the new owner fraction in 2030 would be the be equal to the 10-year average of the historical data (2012-2021) and then decrease to zero by the end of the analysis period (2059). If the resulting fraction of new owners is negative, DOE assumed

[123] U.S. Census, Characteristics of New Housing from 1999-2021 (Available at: *www.census.gov/construction/chars/*) (Last accessed Jan. 3, 2023).
[124] U.S. Census, Characteristics of New Housing (Multi-Family Units) from 1973-2021 (Available at: *www.census.gov/construction/chars/mfu.html*) (Last accessed Jan. 3, 2023).
[125] Home Innovation Research Labs (independent subsidiary of the National Association of Home Builders (NAHB). Annual Builder Practices Survey (2015-2019) (Available at: *www.homeinnovation.com/trends_and_reports/data/new_construction*) (Last accessed Jan. 3, 2023).
[126] Decision Analysts, 2002, 2004, 2006, 2008, 2010, 2013, 2016, 2019, and 2022 American Home Comfort Study (Available at: *www.decisionanalyst.com/Syndicated/HomeComfort/*) (Last accessed Jan. 3, 2023).

that it was primarily due to equipment switching or non-replacement and added this number to replacements (thus reducing the replacements value).

BWC commented that DOE's projections may be overstated because they do not appear to account for how State and local policies will impact the shipments of boilers. As an example, BWC stated that proposed actions by the California Air Resources Board, as well as a few California Air Districts, will push the market away from gas-fired boilers. In addition, BWC stated that there is similar activity in some of the Northeastern States, such as the New Jersey Department of Environmental Protection's all-electric boiler proposal and New York City's all-electric ordinance. (BWC, No. 39 at pp. 2-3) WMT noted that the market is increasingly transitioning towards higher efficiencies without Federal prompting and that this transition is occurring in specific areas and regions where higher-efficiency boilers provide the most financial benefit and the application allows for it. (WMT, No. 32 at p. 11)

For the preliminary analysis, assumptions regarding future policies encouraging higher-efficiency equipment, electrification of households, and electric boilers were speculative at that time, so such policies were not incorporated into the shipments projection. Current requirements in many parts of California for low NOx boilers could increase the cost of these boilers, but it is currently unclear if it will be enough to drive shipments towards other space heating options (including heat pumps). Thus, it is very uncertain to what extent installations of heat pumps would increase at the expense of consumer boiler shipments. DOE agrees that ongoing electrification efforts at various levels of government could impact consumer decisions to switch away from fossil-fuel appliances such as boilers (including recently passed Federal rebates and incentives[127] and proposed 2030 emission standards from the California Air Resource Board[128]), but the Department has limited data on the potential fraction of shipments that might switch from gas- or oil-fired boilers to electric space heating options in the no-new-standards case. For the NOPR analysis, however, DOE was able to refine its shipments analysis and reduce the fraction of gas-fired boilers projected in the future based on most updated saturation data. See chapter 9 of the NOPR TSD for further details.

DOE requests comments on its approach for taking into account electrification efforts in its shipment analysis. DOE also requests comments on other local, State, and Federal policies that may impact the shipments projection of consumer boilers.

AGA, APGA, and NPGA stated that allowing only condensing gas boilers would take away consumer choice. Particularly in the replacement market and where condensing boilers cannot be installed or are cost prohibitive, these commenters argued that consumers will either try to repair the existing gas boiler or change out the gas boiler with an more energy-intensive product such as an electric boiler. (AGA, APGA, and NPGA, No. 38 at p. 3) Similarly, PB Heat stated that increasing the minimum efficiency

[127] The High-Efficiency Electric Home Rebate Act (HEEHRA) provides point-of-sale consumer rebates to enable low- and moderate-income households to electrify their homes. HEEHRA covers 100 percent of electrification project costs (up to item-specific caps) for low-income households and 50 percent of costs (up to item-specific caps) for moderate-income households. The Energy Efficient Home Improvement credit, or 25C, allows households to deduct from their taxes up to 30 percent of the cost of upgrades to their homes, including installing heat pumps, insulation, and importantly, upgrading their breaker boxes to accommodate additional electric load.

[128] See *ww2.arb.ca.gov/sites/default/files/2022-08/2022_State_SIP_Strategy.pdf*; p. 101. The CARB vote that plans to ban gas furnaces and water heaters by 2030, was not the final phase in the process and requires State agencies to draft a rule for phasing out gas-fueled appliances, and then the rule will be under final consideration in 2025.

to condensing levels will drive middle- and lower-income consumers to repair older equipment in order to avoid the high cost of installing a condensing boiler. (PB Heat, No. 34 at p. 2) AHRI stated that the majority of boilers are used in replacement installations and that these replacement locations cannot easily be modified to meet the requirements of condensing equipment, and in some cases, accommodation of condensing equipment is not possible. Therefore, AHRI argued that a condensing standard could potentially lead to increased cases of fuel switching. (AHRI, No. 40 at p. 2)

In response, DOE agrees that a fraction of consumers could elect to repair instead of replace their equipment due to higher efficiency standards. The NOPR analysis accounted for the impact of increased product price for the considered efficiency levels on shipments by incorporating relative price elasticity in the shipments model. This approach gives some weight to the operating cost savings from higher-efficiency products. A price elasticity of demand less than zero reflects the expectation that demand will decrease when prices increase. To model the impact of the increase in relative price from a particular standard level on residential boiler shipments, DOE assumed that the shipments that do not occur represent consumers that would repair their product rather than replace it, extending the life of the product on average by six years in those cases.

For the NOPR, DOE evaluated the potential for switching from gas-fired and oil-fired hot water boilers to other heating systems in response to amended energy conservation standards. The main alternative to hot water boilers would be installation of an electric boiler, a forced-air furnace, a heat pump, or a mini-split heat pump. These alternatives would require significant installation costs such as adding ductwork or an electrical upgrade, and an electric boiler would have very high relative energy costs. Given that the increase in installed cost of boilers meeting the amended standards, relative to the no-new-standards case, is small, DOE has concluded that consumer switching away from hot water boilers due to amended standards would be rare. Therefore, DOE did not analyze fuel switching for consumer boilers for the NOPR.

See chapter 9 of the NOPR TSD for further information on the development of shipments.

H. National Impact Analysis

The NIA assesses the national energy savings (NES) and the NPV from a national perspective of total consumer costs and savings that would be expected to result from new or amended standards at specific efficiency levels.[129] ("Consumer" in this context refers to consumers of the product being regulated.) DOE calculates the NES and NPV for the potential standard levels considered based on projections of annual product shipments, along with the annual energy consumption and total installed cost data from the energy use and LCC analyses. For the present analysis, DOE projected the energy savings, operating cost savings, product costs, and NPV of consumer benefits over the lifetime of consumer boilers sold from 2030 through 2059.

[129] 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 product class in the absence of new or amended energy conservation standards. For this projection, DOE considers historical trends in efficiency and various forces that are likely to affect the mix of efficiencies over time. DOE compares the no-new-standards case with projections characterizing the market for each product class if DOE adopted new or amended standards at specific energy efficiency levels (*i.e.*, the TSLs or standards cases) for that class. For the standards cases, DOE considers how a given standard would likely affect the market shares of products with efficiencies greater than the standard.

DOE uses a spreadsheet model to calculate the energy savings and the national consumer costs and savings from each TSL. Interested parties can review DOE's analyses by changing various input quantities within the spreadsheet. The NIA spreadsheet model uses typical values (as opposed to probability distributions) as inputs.

Table IV.11 summarizes the inputs and methods DOE used for the NIA analysis for the NOPR. Discussion of these inputs and methods follows the table. See chapter 10 of the NOPR TSD for further details.

Table IV.11 Summary of Inputs and Methods for the National Impact Analysis

Inputs	Method
Shipments	Annual shipments from shipments model.
Compliance Date of Standard	2030
Efficiency Trends	No-new-standards case: Based on historical data. Standards cases: Roll-up in the compliance year and then DOE estimated growth in shipment-weighted efficiency in all the standards cases.
Annual Energy Consumption per Unit	Annual weighted-average values are a function of energy use at each TSL.
Total Installed Cost per Unit	Annual weighted-average values are a function of cost at each TSL. Incorporates projection of future product prices based on historical data.
Annual Energy Cost per Unit	Annual weighted-average values as a function of the annual energy consumption per unit and energy prices.
Repair and Maintenance Cost per Unit	Based on RSMeans data and other sources.
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. Section IV.F.8 of this document describes how DOE developed an energy efficiency distribution for the no-new-standards case (which yields a shipment-weighted average efficiency) for each of the considered product classes for the first full year of anticipated compliance with an amended or new standard. To project the trend in efficiency absent amended standards for consumer boilers over the entire shipments projection period, DOE used available historical shipments data and manufacturer input. The approach is further described in chapter 10 of the NOPR TSD.

For the standards cases, DOE used a "roll-up" scenario to establish the shipment-weighted efficiency for the year that standards are assumed to become effective (2030).

In this scenario, the market shares of products in the no-new-standards case that do not meet the standard under consideration would "roll up" to meet the new standard level, and the market share of products above the standard would remain unchanged.

To develop standards-case efficiency trends after 2030, DOE used historical shipment data and current boiler model availability by efficiency level (see chapter 8 of the NOPR TSD). DOE estimated growth in shipment-weighted efficiency by assuming that the implementation of ENERGY STAR's performance criteria and other incentives would gradually increase the market shares of higher-efficiency consumer boilers. DOE also took into account increased incentives for higher-efficiency equipment and electrification efforts.

Crown and U.S. Boilers stated that they expect the growth of condensing boiler market share to slow as the share of remaining non-condensing boiler sales are increasingly confined to difficult installations, as well as situations where the use of condensing boilers makes no economic or technical sense. However, these commenters do not agree with DOE's projected rate of growth decline, a key parameter which would impact the calculation of benefits attributable to an amended standard. (Crown, No. 30 at pp. 15-16; U.S. Boilers, No. 31 at pp. 16-17) AHRI expressed concern that the Department's future shipments model is overly aggressive and suggested that the future shipment projections should be reconsidered at the higher efficiency levels. (AHRI, No. 40 at p. 2)

In response, DOE reviewed recent shipments trends and incentives. Based on the latest data, DOE was able to reassess its growth in condensing boiler shipments, which slightly decreased the projected market share of condensing boilers for use in this NOPR as compared to the preliminary analysis.

DOE requests comments on its approach for developing efficiency trends beyond 2030.

2. National Energy Savings

The national energy savings analysis involves a comparison of national energy consumption of the considered products between each potential standards case (trial standard level (TSL)) and the case with no new or amended energy conservation standards. DOE calculated the national energy consumption by multiplying the number of units (stock) of each product (by vintage or age) by the unit energy consumption (also by vintage). DOE calculated annual NES based on the difference in national energy consumption for the no-new standards case and for each higher-efficiency standard case. DOE estimated energy consumption and savings based on site energy and converted the electricity consumption and savings to primary energy (*i.e.*, the energy consumed by power plants to generate site electricity) using annual conversion factors derived from *AEO2023*. Cumulative energy savings are the sum of the NES for each year over the timeframe of the analysis.

Use of higher-efficiency products is sometimes associated with a direct rebound effect, which refers to an increase in utilization of the product due to the increase in efficiency. DOE did not find any data on the rebound effect specific to consumer boilers. Consequently, DOE applied a rebound effect of 10 percent for consumer boilers used in residential applications based on studies of other residential products and 0 percent for consumer boilers used in commercial applications. The calculated NES at each efficiency level is, therefore, reduced by 10 percent in residential applications. DOE also included the rebound effect in the NPV analysis by accounting for the additional net benefit from increased consumer boiler usage, as described in section IV.H.3 of this document.

DOE requests comments and any data on the potential for direct rebound.

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 (August 18, 2011). After evaluating the approaches discussed in the August 18, 2011 notice, DOE published a statement of amended policy in which DOE explained its determination that EIA's National Energy Modeling System (NEMS) is the most appropriate tool for its FFC analysis and its intention to use NEMS for that purpose. 77 FR 49701 (August 17, 2012). NEMS is a public domain, multisector, partial equilibrium model of the U.S. energy sector[130] that EIA uses to prepare its *Annual Energy Outlook*. 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 10B of the NOPR TSD.

3. Net Present Value Analysis

The inputs for determining the NPV of the total costs and benefits experienced by consumers are: (1) total annual installed cost; (2) total annual operating costs (energy costs and repair and maintenance costs), and (3) a discount factor to calculate the present value of costs and savings. DOE calculates net savings each year as the difference between the no-new-standards case and each standards case in terms of total savings in operating costs versus total increases in installed costs. DOE calculates operating cost savings over the lifetime of each product shipped during the projection period.

As discussed in section IV.F.1 of this document, DOE developed consumer boiler price trends based on historical PPI data. DOE applied the same trends to project prices for each product class at each considered efficiency level. To evaluate the effect of uncertainty regarding the price trend estimates, DOE investigated the impact of different product price projections on the consumer NPV for the considered TSLs for consumer

[130] For more information on NEMS, refer to *The National Energy Modeling System: An Overview 2018*, DOE/EIA-0383(2018) (April 2019) (Available at: *www.eia.gov/forecasts/aeo/index.cfm*) (Last accessed Jan. 3, 2023).

boilers. In addition to the default constant price trend, DOE considered two product price sensitivity cases: (1) a high-price case based on an exponential fit of deflated heating equipment PPI from 1980 to 2021 and (2) a low-price case based on an exponential fit of deflated steel heating boiler PPI from 1980 to 1998 (partially extrapolated). The derivation of these price trends and the results of these sensitivity cases are described in appendix 10C of the NOPR TSD.

The energy cost savings are calculated using the estimated energy savings in each year and the projected price of the appropriate form of energy. To estimate energy prices in future years, DOE multiplied the average regional energy prices by the projection of annual national-average residential and commercial energy price changes in the Reference case from *AEO 2023*, which has an end year of 2050. To estimate price trends after 2050, DOE used a constant value derived from the average value between 2046 through 2050. As part of the NIA, DOE also analyzed scenarios that used inputs from variants of the *AEO 2023* 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 10D of the NOPR TSD.

In considering the consumer welfare gained due to the direct rebound effect, DOE accounted for change in consumer surplus attributed to additional cooling from the purchase of a more-efficient unit. Overall consumer welfare is generally understood to be enhanced from rebound (*i.e.*, a measure of the enjoyment the boiler consumer receives through additional heating comfort). The net consumer impact of the rebound effect is included in the calculation of operating cost savings in the consumer NPV results. See appendix 10E of the NOPR TSD for details on DOE's treatment of the monetary valuation of the rebound effect.

DOE requests comments on its approach to monetizing the impact of the rebound effect.

In calculating the NPV, DOE multiplies the net savings in future years by a discount factor to determine their present value. For this NOPR, DOE estimated the NPV of consumer benefits using both a 3-percent and a 7-percent real discount rate. DOE uses these discount rates in accordance with guidance provided by the Office of Management and Budget (OMB) to Federal agencies on the development of regulatory analysis.[131] The discount rates for the determination of NPV are in contrast to the discount rates used in the LCC analysis, which are designed to reflect a consumer's perspective. The 7-percent real value is an estimate of the average before-tax rate of return to private capital in the U.S. economy. The 3-percent real value represents the "social rate of time preference," which is the rate at which society discounts future consumption flows to their present value.

I. Consumer Subgroup Analysis

In analyzing the potential impact of new or amended energy conservation standards on consumers, DOE evaluates the impact on identifiable subgroups of consumers that may be disproportionately affected by a new or amended national

[131] United States Office of Management and Budget. Circular A-4: Regulatory Analysis (Sept. 17, 2003) Section E (Available at: *obamawhitehouse.archives.gov/omb/circulars_a004_a-4/*) (Last accessed Jan. 3, 2023).

standard. The purpose of a subgroup analysis is to determine the extent of any such disproportional impacts. DOE evaluates impacts on particular subgroups of consumers by analyzing the LCC impacts and PBP for those particular consumers from alternative standard levels. For this NOPR, DOE analyzed the impacts of the considered standard levels on three subgroups: (1) low-income households; (2) senior-only households, and (3) small businesses. The analysis used subsets of the RECS 2015 and CBECS 2018 samples composed of households or commercial settings that meet the criteria for the three subgroups. DOE used the LCC and PBP spreadsheet model to estimate the impacts of the considered efficiency levels on these subgroups. Chapter 11 in the NOPR TSD describes the consumer subgroup analysis.

J. Manufacturer Impact Analysis

1. Overview

DOE performed an MIA to estimate the financial impacts of amended energy conservation standards on manufacturers of consumer boilers and to estimate the potential impacts of such standards on direct employment and manufacturing capacity. The MIA has both quantitative and qualitative aspects and includes analyses of projected industry cash flows, the INPV, investments in research and development (R&D) and manufacturing capital, and domestic manufacturing employment. Additionally, the MIA seeks to determine how amended energy conservation standards might affect manufacturing employment, capacity, and competition, as well as how standards contribute to overall regulatory burden. Finally, the MIA serves to identify any disproportionate impacts on manufacturer subgroups, including small business manufacturers.

The quantitative part of the MIA primarily relies on the Government Regulatory Impact Model (GRIM), an industry cash flow model with inputs specific to this rulemaking. The key GRIM inputs include data on the industry cost structure, unit production costs, product shipments, gross margin percentages (*i.e.*, manufacturer markups), and investments in R&D and manufacturing capital required to produce compliant products. The key GRIM outputs are the INPV, which is the sum of industry annual cash flows over the analysis period, discounted using the industry-weighted average cost of capital, and the impact to domestic manufacturing employment. The model uses standard accounting principles to estimate the impacts of more-stringent energy conservation standards on a given industry by comparing changes in INPV and domestic manufacturing employment between a no-new-standards case and the various standards cases (*i.e.*, TSLs). To capture the uncertainty relating to manufacturer pricing strategies following amended standards, the GRIM estimates a range of possible impacts under different manufacturer markup scenarios.

The qualitative part of the MIA addresses manufacturer characteristics and market trends. Specifically, the MIA considers such factors as a potential standard's impact on manufacturing capacity, competition within the industry, the cumulative impact of other DOE and non-DOE regulations, and impacts on manufacturer subgroups. The complete MIA is outlined in chapter 12 of the NOPR TSD.

DOE conducted the MIA for this rulemaking in three phases. In Phase 1 of the MIA, DOE prepared a profile of the consumer boiler manufacturing industry based on the market and technology assessment, preliminary manufacturer interviews, and publicly-available information. This included a top-down analysis of consumer boiler manufacturers that DOE used to derive preliminary financial inputs for the GRIM (*e.g.*, revenues; materials, labor, overhead, and depreciation expenses; selling, general, and administrative expenses (SG&A); and R&D expenses). DOE also used public sources of information to further calibrate its initial characterization of the consumer boiler manufacturing industry, including company filings of form 10-K from the SEC,[132] corporate annual reports, the U.S. Census Bureau's *Annual Survey of Manufactures* (*ASM*) ,[133] and reports from Dun & Bradstreet.[134]

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.

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[132] U.S. Securities and Exchange Commission, *Electronic Data Gathering, Analysis, and Retrieval (EDGAR) system* (Available at: *www.sec.gov/edgar/search/*) (Last accessed Jan. 3, 2023).
[133] U.S. Census Bureau, *Annual Survey of Manufactures*. "Summary Statistics for Industry Groups and Industries in the U.S (2021)" (Available at: *www.census.gov/data/tables/time-series/econ/asm/2018-2021-asm.html*) (Last accessed Jan. 3, 2023).
[134] The Dun & Bradstreet Hoovers login is available at: *app.dnbhoovers.com* (Last accessed Jan. 3, 2023).

In addition, during Phase 2, DOE developed interview guides to distribute to manufacturers of consumer boilers 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, manufacturing, procurement, and financial topics to validate assumptions used in the GRIM and to identify key issues or concerns. See section IV.J.3 of this document for a description of the key issues raised by manufacturers during the interviews. As part of Phase 3, DOE also evaluated subgroups of manufacturers that may be disproportionately impacted by amended standards or that may not be accurately represented by the average cost assumptions used to develop the industry cash-flow analysis. Such manufacturer subgroups may include small business manufacturers, low-volume manufacturers, niche players, and/or manufacturers exhibiting a cost structure that largely differs from the industry average. DOE identified two manufacturer subgroups for a separate impact analysis: (1) small business manufacturers and (2) OEMs that own domestic foundry assets. The small business subgroup is discussed in section VI.B, "Review under the Regulatory Flexibility Act," and the OEMs that own domestic foundry assets subgroup is discussed in section V.B.2.d of this document and in chapter 12 of the NOPR 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 amended energy conservation standards. The GRIM spreadsheet uses the inputs to arrive at a series of annual cash flows, beginning in 2023 (the base year of the analysis) and continuing to 2059. DOE calculated INPVs by summing the stream of annual discounted cash flows during this period. For manufacturers of consumer boilers, DOE used a real discount rate of 9.7 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, results of the shipments analysis, and information gathered from industry stakeholders during the course of manufacturer interviews. 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 NOPR TSD.

a. Manufacturer Production Costs

Manufacturing more-efficient products is typically more expensive than manufacturing baseline products due to the use of more complex components, which are typically more costly than baseline components. The changes in the MPCs of covered products can affect the revenues, gross margins, and cash flow of the industry. For this rulemaking, DOE relied on the efficiency-level approach. This approach ensures that the efficiency levels considered in the engineering analysis are attainable using technologies which are commercially available and viable for consumer boilers. As such, DOE was able to conduct teardown analyses on consumer boilers which meet each efficiency level, and, thus, ascertain a list of representative design options which manufacturers are most likely to employ in order to achieve these efficiencies. For a complete description of the MPCs, see chapter 5 of the NOPR TSD or section IV.C of this document.

b. Shipments Projections

The GRIM estimates manufacturer revenues based on total unit shipment projections and the distribution of those shipments by efficiency level. Changes in sales volumes and efficiency mix over time can significantly affect manufacturer finances. For this analysis, the GRIM uses the NIA's annual shipment projections derived from the shipments analysis from 2023 (the base year) to 2059 (the end year of the analysis period). See chapter 9 of the NOPR TSD or section IV.G of this document for additional details.

c. Product and Capital Conversion Costs

Amended energy conservation standards could cause manufacturers to incur conversion costs to bring their production facilities and product 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.

DOE based its estimates of the product conversion costs necessary to meet the varying efficiency levels on information from manufacturer interviews, design pathways analyzed in the engineering analysis, and market share and model count information. During confidential interviews, DOE asked manufacturers to estimate the redesign effort and engineering resources required at various efficiency levels to quantify the product conversion costs. Manufacturer data were aggregated to better reflect the industry as a whole and to protect confidential information. DOE scaled product conversion costs by the number of models that would require redesign to account for the portion of companies that were not interviewed. Such approach allows DOE to arrive at an industry-wide conversion cost estimate.

DOE relied on information derived from manufacturer interviews and the engineering analysis to evaluate the level of capital conversion costs manufacturers would likely incur at the analyzed efficiency levels. During interviews, manufacturers provided estimates and descriptions of the required tooling and plant changes that would be necessary to upgrade product lines to meet the various efficiency levels. DOE used estimates of capital expenditure requirements derived from the product teardown analysis and engineering analysis to validate manufacturer feedback. For non-condensing efficiency levels above baseline, DOE estimated that manufacturers would require new tooling for some new casting designs. For efficiency levels requiring condensing technology, DOE estimated that manufacturers with a significant volume of non-condensing gas-fired hot water boilers would incur large capital conversion costs to develop additional assembly lines for condensing boilers. Based on manufacturer feedback, DOE assumed manufacturers would continue to source condensing heat exchangers and would not shift to in-house manufacturing of condensing heat exchangers. DOE estimated industry capital conversion costs by extrapolating the interviewed manufacturers' capital conversion costs for each product class to account for the market share of companies that were not interviewed.

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 amended 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 and product conversion costs, see chapter 12 of the NOPR TSD.

d. Manufacturer Markup Scenarios

MSPs include direct manufacturing production costs (*i.e.*, labor, materials, and overhead estimated in DOE's MPCs) and all non-production costs (*i.e.*, SG&A, R&D, and interest), along with profit. To calculate the MSPs in the GRIM, DOE applied manufacturer markups to the MPCs estimated in the engineering analysis for each 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 scenarios to represent uncertainty regarding the potential impacts on prices and profitability for manufacturers following the implementation of amended energy conservation standards: (1) a preservation of gross margin percentage scenario; and (2) a preservation of operating profit scenario. These scenarios lead to different manufacturer markup values that, when applied to the MPCs, result in varying revenue and cash-flow impacts on manufacturers.

Under the preservation of gross margin percentage scenario, DOE applied a single uniform "gross margin percentage" markup across all product classes and all efficiency levels (including baseline efficiency), which assumes that manufacturers would be able to maintain the same amount of profit as a percentage of revenues at all efficiency levels within a product class. As manufacturer production costs increase with efficiency, this scenario implies that the per-unit dollar profit will increase. DOE assumed a gross margin percentage of 29 percent for all product classes.[135] Manufacturers tend to believe it is optimistic to assume that they would be able to maintain the same gross margin

[135] The gross margin percentage of 29 percent is based on a manufacturer markup of 1.41.

percentage as their production costs increase, particularly for minimally-efficient products. Therefore, this scenario represents a high bound of industry profitability under an amended energy conservation standard.

Under the preservation of operating profit scenario, as the cost of production goes up under a standards case, manufacturers are generally required to reduce their manufacturer markups to a level that maintains base-case operating profit. DOE implemented this scenario in the GRIM by lowering the manufacturer markups at each TSL to yield approximately the same earnings before interest and taxes in the standards case as in the no-new-standards case in the year after the expected compliance date of the amended energy conservation standards. The implicit assumption behind this scenario is that the industry can only maintain its operating profit in absolute dollars after the standard takes effect. Therefore, operating profit in percentage terms is reduced between the no-new-standard case and the standards cases. This scenario represents a lower bound of industry profitability under an amended energy conservation standard.

A comparison of industry financial impacts under the two manufacturer markup scenarios is presented in section V.B.2 of this document.

3. Manufacturer Interviews

DOE interviewed manufacturers representing approximately 45 percent of the domestic consumer boiler shipments. Participants included a cross-section of domestic-based and foreign-based OEMs. Participants included manufacturers with a wide range of market shares and product class offerings.

In interviews, DOE asked manufacturers to describe their major concerns regarding potential more-stringent energy conservation standards for consumer boilers. The following section highlights manufacturer concerns that helped inform the projected potential impacts of an amended standard on the industry. Manufacturer interviews are conducted by DOE consultants under non-disclosure agreements (NDAs), so the Department does not document these discussions in the same way that it does public comments, in terms of providing comment summaries and DOE's responses throughout the rest of this document.

a. The Replacement Market

In interviews, several manufacturers discussed the potential challenges and benefits of moving to a condensing standard for consumer boilers.

Several manufacturers estimated that, on average, between 80 to 90 percent of consumer boiler sales are through the replacement market, rather than the new construction channel. They noted that since condensing and non-condensing products require different venting infrastructure, a condensing standard could lead to higher installation costs for the consumer, as well as technical and/or safety challenges with installation and operation, in certain cases. Some manufacturers stated that since the current consumer boiler market is structured around the legacy venting infrastructures that exist in most homes, raising standards on gas-fired hot water boilers above 84-percent AFUE would be very disruptive to the market.

Other manufacturers noted that while it may be expensive to replace a non-condensing boiler with a condensing boiler in some instances, there are pathways to complete installations safely. They requested that DOE account for the higher installation costs in analyses, rather than creating separate product classes for non-condensing consumer boilers.

4. Discussion of MIA Comments

AHRI noted that small OEMs will be impacted by this rulemaking, especially with respect to cast-iron boilers. (AHRI, No. 40 at p. 6) AHRI recommended that the Department should give more weight to the consideration of State-level impact on consumers and small manufacturers instead of the use of a national average value for those subgroups. (AHRI, No. 40 at p. 2)

In response, DOE evaluated subgroups of manufacturers that may be disproportionately impacted by amended standards, including small business manufacturers. DOE identified three small, domestic OEMs of covered consumer boilers. Regarding the impact on small manufacturers, see section VI.B of this document for a discussion of the potential impact of amended energy conservation standards for consumer boilers on the three small OEMs identified. The distributional impacts of a potential standard, which capture State-level differences, are part of the LCC analysis (*see* section IV.F of this document). Specific subgroups, including small businesses, are part of the subgroup analysis (*see* section IV.I of this document). The aggregate national impacts are part of the NIA (*see* section IV.H of this document). All of these analyses are considered by DOE when making a determination of economic justification, per EPCA requirements.

In response to the May 2022 Preliminary Analysis, Crown, U.S. Boiler, WMT, PB Heat, BWC, and AHRI stated that the adoption of a condensing standard will likely have a disproportionate, negative impact on domestic manufacturers (Crown, No. 30 at pp. 16-17; U.S. Boiler, No. 31 at pp 17-18; WMT, No. 32 at p. 12; PB Heat, No. 34 at p. 2; BWC, No. 39 at p. 4; AHRI, No. 40 at p. 7) Crown, U.S. Boiler, and WMT emphasized that, in particular, manufacturers with foundries would be disproportionally affected by potential amended energy conservation standards for consumer boilers. (Crown, No. 30 at pp. 16-17; U.S. Boiler, No. 31 at pp 17-18; WMT, No. 32 at p. 12) Stakeholders commented on a range of potential negative impacts of more stringent standards, including: (1) increases in cast-iron prices in other boiler types; (2) possible foundry closures; (3) potential job losses associated with foundry operation, casting, and assembly, which could lead to a reduction in domestic manufacturing employment; and (4) significant stranded assets. The following paragraphs discuss these stakeholder concerns in detail.

Crown, U.S. Boiler, WMT, and AHRI commented that raising the gas-fired hot water standard to a condensing level would result in increased manufacturing costs for the other cast-iron product classes, even if the standards for those classes were to be left unchanged. (Crown, No. 30 at pp. 5-6; U.S. Boiler, No. 31 at pp. 5-6; WMT, No. 32 at p. 12; AHRI, No. 40 at p. 7) Crown and U.S. Boiler stated that this is because the cast-iron foundries producing heat exchangers for non-condensing boilers have large, fixed costs that would no longer be shared with gas-fired hot water consumer boilers. (Crown, No. 30 at pp. 5-6; U.S. Boiler, No. 31 at pp. 5-6) WMT noted that the cost structure of cast-iron boiler manufacturers is different from most other businesses. WMT stated that because of the similarity of cast-iron heat exchanger designs between product classes, a reduction in the annual volume of the larger product class (*i.e.,* gas-fired hot water) will have a significant cost impact upon the lower-volume product classes. (WMT, No. 32 at p. 12) AHRI claimed that eliminating non-condensing gas-fired boilers will cause an increase in the cost of cast-iron heat exchangers, which would largely impact the steam boiler replacement market. Furthermore, AHRI asserted that due to the similarity of cast iron heat exchangers for hot water boilers and steam boilers, a reduction in the annual volume of the gas-fired hot water category will have a significant cost impact upon the smaller product categories of gas-fired steam, oil-fired hot water, and oil-fired steam boilers. (AHRI, No. 40 at p. 7)

As noted in section IV.C.2 of this document, research indicates that most consumer boiler OEMs use third-party foundries for their boiler castings. For the consumer boiler OEMs that own foundry assets, DOE analyzes the disproportionate impacts of a condensing standard on those manufacturers in section V.B.2.d of this document, "Impacts on Subgroups of Manufacturers." As discussed in detail in section V.B.2.d of this document, DOE used the engineering analysis to estimate the depreciation and overhead associated with an average gas-fired hot water cast-iron heat exchanger. Next, DOE used the shipments analysis and estimated market share of boilers produced by vertically integrated OEMs (*i.e.*, consumer boiler OEMs with foundry assets and in-house casting) to estimate the amount depreciation and overhead that would potentially need to be reallocated to the remaining cast-iron product classes under a condensing standard. DOE then modeled two manufacturer markup scenarios to understand the range of potential impacts for foundry-owners. This modeling resulted in higher production costs and reduced profitability for foundry-owners. See section V.B.2.d of this document for further details.

Crown, U.S. Boiler, and WMT indicated that some foundries may no longer be commercially viable under a condensing gas-fired hot water standard. (Crown, No. 30 at pp. 5-6; U.S. Boiler, No. 31 at pp. 5-6; WMT, No. 32 at p. 12) Crown and U.S. Boiler indicated that foundry closure could lead to reduced availability of gas-fired steam, oil-fired hot water, and/or oil-fired steam boilers and higher costs for new boilers and replacement parts. (Crown, No. 30 at pp. 5-6; U.S. Boiler, No. 31 at pp. 5-6) WMT stated that an increase in efficiency standards would result in, "closing of at least one cast iron foundry within the United States." (WMT, No. 32 at p. 12) Crown and U.S. Boiler noted that foundries engaged in manufacturing cast-iron boilers are almost exclusively located in the U.S., including their casting supplier, Casting Solutions, located in Zanesville, Ohio. (Crown, No. 30 at p. 16; U.S. Boiler, No. 31 at p. 17)

In response, DOE initially identified three foundries in the United States that supply castings for the domestic consumer boiler market. DOE identified these foundries using publicly-available information and verified the information in confidential manufacturer interviews. Of these three foundries, two are owned by consumer boiler OEMs. The remaining foundry, located in Waupaca, Wisconsin, provides castings for a range of markets (*e.g.,* automotive, rail, industrial). In the GRIM, DOE assumes both

OEMs maintain their foundries under a condensing standard. The subgroup analysis modeling resulted in higher production costs and reduced profitability for foundry-owners. DOE discusses the potential impacts of amended standards on OEMs that own foundry assets in section V.B.2.d of this document.

Crown, U.S. Boiler, WMT, PB Heat, BWC, and AHRI all asserted that amended standards would lead to a loss of American jobs and the need to import heat exchangers for consumer boilers from overseas. (Crown, No. 30 at pp. 16-17; U.S. Boiler, No. 31 at pp. 17-18; WMT, No. 32 at p. 12; PB Heat, No. 34 at p. 2; BWC, No. 39 at p. 4; AHRI, No. 40 at p. 7)

Crown and U.S. Boiler stated that raising standards for gas-fired hot water consumer boilers would have devasting impacts on cast-iron manufacturers. As a specific example, they discussed that their casting provider, Casting Solutions (a division of their parent company, Burnham Holdings, Inc. (BHI)) currently employs over 100 people, with most of them being union manufacturing workers. The commenters argued that in addition to potential foundry job losses, there are other manufacturing jobs associated with machining castings and assembling cast-iron boilers at several BHI divisions that would be at risk, including approximately 89 jobs at U.S. Boiler's manufacturing facility and approximately 30 jobs at Crown's manufacturing facility, which is located in a "depressed inner-city Philadelphia neighborhood." (Crown, No. 30 at pp. 16-17; U.S. Boiler, No. 31 at pp. 17-18)

BWC recommended that DOE should account for the substantial percentage of high-efficiency consumer boilers that are produced by foreign manufacturers as part of this rulemaking, as well as key components in condensing boilers, such as stainless-steel heat exchangers. (BWC, No. 39 at p. 4) AHRI urged the Department to examine the impact on jobs as a result of a condensing rule, as well as examining the cost of importing heat exchangers from foreign sources (including increased shipping costs and any tariffs). (AHRI, No. 40 at p. 7)

Regarding the potential job losses associated with a potential condensing standard for consumer boilers, DOE analyzes the potential impact of amended standards on domestic direct employment as part of the MIA. DOE estimates that over 90 percent of non-condensing consumer boilers, including key components such as cast-iron heat exchangers, are manufactured in the United States, whereas approximately 60 percent of condensing consumer boilers are manufactured in the United States. DOE recognizes that key components for condensing gas-fired hot water boilers, such as stainless-steel condensing heat exchangers are manufactured outside of the United States. Furthermore, developing an in-house condensing heat exchanger production line would require large upfront investments, which may not be cost-effective given the relatively low levels of domestic gas-fired boiler sales compared to other markets. Therefore, DOE has tentatively concluded that setting a condensing standard for gas-fired hot water boilers, which accounts for approximately 75 percent of annual boiler shipments, would likely lead to a reduction in domestic direct employment in the consumer boiler industry in the range of 14 to 61 jobs, depending on the adopted standard level. See section V.B.2.b of this document for analysis of impacts on direct employment.

Regarding the cost of importing heat exchangers from foreign sources, manufacturers provided feedback on the current cost of imported heat exchangers, which includes inbound freight costs and tariffs, during manufacturer interviews. DOE incorporated this feedback into its analysis when developing its MPCs, and, thus, these impacts are accounted for as a portion of the cost for purchased parts. See section IV.C.2 of this document for additional details on the cost analysis and MPCs.

Crown, U.S. Boiler, and WMT asserted that adoption of a condensing standard, at a minimum, would strand millions of dollars in assets, including gas-fired hot water cast-iron section patterns. (Crown, No. 30 at p. 16; U.S. Boiler, No. 31 at p. 17; WMT, No. 32 at p. 12)

In response, DOE incorporates the estimated stranded assets (*i.e.,* the residual un-depreciated value of tooling and equipment that would have enjoyed longer use if amended energy conservation standard had not made them obsolete) for each analyzed standard case into its model. In the GRIM, the remaining book value of existing tooling and equipment, the value of which is affected by the amended energy conservation standards, acts as a tax shield that mitigates decreases in cash flow from operations in the year of the write-down. To estimate potential stranded assets, DOE relied on manufacturer feedback, SEC 10-K filings of relevant consumer boiler OEMs, and results of the engineering analysis. See chapter 12 of the NOPR TSD for additional details on stranded assets.

WMT indicated that cumulative regulatory burden is experienced from rulemakings pertaining to consumer boilers, commercial water heaters, small electric motors, furnace fans, and others. (WMT, No. 32 at p. 12) AHRI requested that DOE evaluate the regulatory burden that will be placed on consumer as well as manufacturers. (AHRI, No. 40 at p. 2)

Rheem stated that due to the numerous products facing amended standards, an overwhelming majority of manufactures will face increased burden in the coming years for product redesigns and compliance. The commenter urged DOE to place more emphasis on identifying and mitigating manufacturers burden when amending energy conservation standards for water heating, boilers, and pool heating products and equipment. Rheem also supported AHRI's comments on cumulative burden on consumers, noting the increased financial burden placed on them due to amended standards (*e.g.*, higher purchase prices, higher repair rates). (Rheem, No. 37 at p. 6)

In response, DOE notes that it analyzes cumulative regulatory burden pursuant to section 13(g) of appendix A. See section V.B.2.e of this document for a list of DOE regulations that affect consumer boiler manufacturers that could take effect approximately three years before or after the expected 2030 compliance date of amended energy conservation standards for consumer boilers. At the time of publication, DOE notes that amended energy conservation standards have not been proposed for furnace fans.[136] Regarding small electric motors, as detailed in the notice of proposed

[136] See *www1.eere.energy.gov/buildings/appliance_standards/standards.aspx?productid=54* (Last accessed Jan. 3, 2023).

determination published in the *Federal Register* on February 6, 2023, DOE has tentatively determined that more-stringent energy conservation standards would not be cost-effective. 88 FR 7629. If DOE proposes or finalizes any energy conservation standards for these products prior to finalizing energy conservation standards for consumer boilers, DOE will include the energy conservation standards for these other products as part of its consideration of cumulative regulatory burden for this consumer boiler's rulemaking.

Although DOE does not analyze the cumulative burden on consumers, section V.B.1.a of this document discusses the economic impact of amended standards on individual consumers, which is the main impact consumers will face with a finalized energy conservation standards.

K. Emissions Analysis

The emissions analysis consists of two components. The first component estimates the effect of potential energy conservation standards on power sector and site (where applicable) combustion emissions of CO_2, NO_X, SO_2, and Hg. The second component estimates the impacts of potential standards on emissions of two additional greenhouse gases, CH_4 and N_2O, as well as the reductions to 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 NOPR TSD. The analysis presented in this document uses projections from *AEO 2023*. 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).[137]

The on-site operation of consumer boilers requires combustion of fossil fuels and results in emissions of CO_2, NO_X, SO_2 CH_4 and N_2O where these products are 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.[138]

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 NOPR TSD.

The emissions intensity factors are expressed in terms of physical units per MWh or MMBtu of site energy savings. For power sector emissions, specific emissions

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[137] Available at www.epa.gov/system/files/documents/2023-03/ghg_emission_factors_hub.pdf (Last accessed May 3, 2023).
[138] 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/ttn/chief/ap42/index.html)* (Last accessed Jan. 3, 2023).

intensity factors are calculated by sector and end use. Total emissions reductions are estimated using the energy savings calculated in the national impact analysis.

1. Air Quality Regulations Incorporated in DOE's Analysis

DOE's no-new-standards case for the electric power sector reflects the *AEO*, which incorporates the projected impacts of existing air quality regulations on emissions. *AEO 2023* generally represents current legislation and environmental regulations, including recent government actions, that were in place at the time of preparation of *AEO 2023*, including the emissions control programs discussed in the following paragraphs.[139]

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 (August 8, 2011). CSAPR requires these States to reduce certain emissions, including annual SO_2 emissions, and went into effect as of January 1, 2015.[140] *AEO 2023* incorporates implementation of CSAPR, including the

[139] For further information, see the Assumptions to *AEO 2023* 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 May 3, 2023).

[140] CSAPR requires States to address annual emissions of SO2 and NOX, precursors to the formation of fine particulate matter (PM2.5) pollution, in order to address the interstate transport of pollution with respect to the 1997 and 2006 PM2.5 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 (August 8, 2011). EPA subsequently published a supplemental rule that included an additional five States in the CSAPR ozone season program (76 FR 80760 (Dec. 27, 2011)) (Supplemental Rule).

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, 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 power plants must have either flue gas desulfurization or dry sorbent injection systems installed. Both technologies, which are used to reduce acid gas emissions, also reduce SO_2 emissions. 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 would generally reduce SO_2 emissions. DOE estimated SO_2 emissions reduction using emissions factors based on *AEO 2023*.

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. A different case could possibly result, depending on the configuration of the power sector in the different regions and the need for allowances, such that NO_X emissions might not remain at the limit in the case of lower electricity demand. In this case, 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. Energy conservation standards would be expected to reduce NO_X emissions in the States not covered by CSAPR. DOE used *AEO 2023* data to derive NO_X emissions factors for the group of States not covered by CSAPR.

The MATS limit mercury emissions from power plants, but they do not include emissions caps, and, as such, DOE's energy conservation standards would be expected to slightly reduce Hg emissions. DOE estimated mercury emissions reduction using emissions factors based on *AEO 2023*, which incorporates the MATS.

WMT expressed concern over the reliance upon the emissions impact analysis in the energy conservation standards rulemaking due to its potential to be controversial in light of the Supreme Court ruling on *West Virginia v. EPA* and the "major question doctrine" cited therein. (WMT, No. 32 at p. 2) In response, 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, which is required by EPCA. (42 U.S.C. 6295(o)(2)(B)(i)(VI)) In addition, DOE's emissions impact analysis is consistent with its Procedures, Interpretations, and Policies for Consideration in New or Revised Energy Conservation Standards and Test Procedures for Consumer Products and Commercial/Industrial Equipment.[141] Furthermore, DOE considers potential emissions and related health benefits as a separate analysis from the consumer, manufacturer, and national impact analyses. As discussed in section V.C of this document, DOE's proposed standards are justified under EPCA even without consideration of those additional emissions and health benefits.

L. Monetizing Emissions Impacts

As part of the development of this proposed rule, for the purpose of complying with the requirements of Executive Order 12866, DOE considered the estimated monetary benefits from the reduced emissions of CO_2, CH_4, N_2O, NO_X, and SO_2 that are expected to result from each of the TSLs considered. In order to make this calculation analogous to the calculation of the NPV of consumer benefit, DOE considered the reduced emissions expected to result over the lifetime of products shipped in the projection period for each TSL. This section summarizes the basis for the values used for monetizing the emissions benefits and presents the values considered in this NOPR.

[141] See *www.regulations.gov/document/EERE-2021-BT-STD-0003-0075.*

To monetize the benefits of reducing GHG emissions, this analysis uses the interim estimates presented in the Technical Support Document: Social Cost of Carbon, Methane, and Nitrous Oxide Interim Estimates Under Executive Order 13990 published in February 2021 by the IWG.

1. Monetization of Greenhouse Gas Emissions

DOE estimates the monetized benefits of the reductions in emissions of CO_2, CH_4, and N_2O by using a measure of the 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 proposed rulemaking in the absence of the social cost of greenhouse gases. That is, the social costs of greenhouse gases, whether measured using the February 2021 interim estimates presented by the Interagency Working Group on the Social Cost of Greenhouse Gases 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 using SC-GHG values that were based on the interim values presented in the *Technical Support Document: Social Cost of Carbon, Methane, and Nitrous Oxide Interim Estimates under Executive Order 13990*, published in February 2021 by the IWG. 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-GHGs 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-GHGs, therefore, reflects the societal value of reducing emissions of the gas in question by one metric ton. The SC-GHGs is the theoretically appropriate value to use in conducting benefit-cost analyses of policies that affect CO_2, N_2O, and CH_4 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 with 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 social cost of carbon (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 – 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 social cost of methane (SC-CH_4) and nitrous oxide (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.*[142]and underwent a standard double-blind peer review process prior to journal publication. 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

[142] Marten, A. L., E. A. Kopits, C. W. Griffiths, S. C. Newbold, and A. Wolverton, Incremental CH4 and N2O mitigation benefits consistent with the U.S. Government's SC-CO2 estimates. *Climate Policy* (2015) 15(2): pp. 272–298.

to various components of the estimation process (National Academies, 2017).[143] Shortly thereafter, in March 2017, President Trump issued Executive Order 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" (EO 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.

On January 20, 2021, President Biden issued Executive Order 13990, which re-established the IWG and directed it to ensure that the U.S. Government's estimates of the social cost of carbon and other greenhouse gases reflect the best available science and the recommendations of the National Academies (2017). 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 E.O. 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 proposed rulemaking. The E.O. instructs the IWG to undertake a fuller update of the

[143] 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.

SC-GHG estimates by January 2022 that takes into consideration the advice of the National Academies (2017) 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, and tourism, as well as 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 U.S. 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 proposed 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 U.S. 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 (2017) 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,[144] 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 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

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[144] 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 Jan. 3, 2023) (Available at: *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) (Available at: *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 Jan. 3, 2023) (Available at: *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) (Available at: *www.epa.gov/sites/default/files/2016-12/documents/addendum_to_sc-ghg_tsd_august_2016.pdf*) (Last accessed Jan. 3, 2023).

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 social cost of greenhouse gases 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 this 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.[145] 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 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 proposed rule likely underestimate the damages from GHG emissions. DOE concurs with this assessment.

[145] 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/*) (Last accessed Jan. 3, 2023).

DOE's derivations of the SC-GHG (*i.e.*, SC-CO_2, SC-N_2O, and SC-CH_4) values used for this NOPR 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 NOPR were based on the values developed for the IWG's February 2021 TSD, which are shown in Table IV.4 in five-year increments from 2020 to 2050. The set of annual values that DOE used, which was adapted from estimates published by EPA,[146] is presented in Appendix 14-A of the NOPR TSD. These estimates are based on methods, assumptions, and parameters identical to the estimates published by the IWG (which were based on EPA modeling), and include values for 2051 to 2070. DOE expects additional climate benefits to accrue for products still operating after 2070, but a lack of available SC-CO_2 estimates for emissions years beyond 2070 prevents DOE from monetizing these potential benefits in this analysis.

For purposes of capturing the uncertainties involved in regulatory impact analysis, DOE has determined it is appropriate include all four sets of SC-CO_2 values, as recommended by the IWG.[147]

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[146] *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 February 21, 2023).

[147] 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.

Table IV.12 Annual SC-CO_2 Values from 2021 Interagency Update, 2020–2050 (2020$ per Metric Ton CO_2)

Year	Discount Rate and Statistic			
	5% Average	3% Average	2.5% Average	3% 95th percentile
2020	14	51	76	152
2025	17	56	83	169
2030	19	62	89	187
2035	22	67	96	206
2040	25	73	103	225
2045	28	79	110	242
2050	32	85	116	260

DOE multiplied the CO_2 emissions reduction estimated for each year by the SC-CO_2 value for that year in each of the four cases. DOE adjusted the values to 2022$ using the implicit price deflator for gross domestic product (GDP) from the Bureau of Economic Analysis. To calculate a present value of the stream of monetary values, DOE discounted the values in each of the four cases using the specific discount rate that had been used to obtain the SC-CO_2 values in each case.

b. Social Cost of Methane and Nitrous Oxide

The SC-CH_4 and SC-N_2O values used for this NOPR were based on the values developed for the February 2021 TSD. Table IV.13 shows the updated sets of SC-CH_4 and SC-N_2O estimates from the latest interagency update in 5-year increments from 2020 to 2050. The full set of annual values used is presented in appendix 14-A of the NOPR TSD. To capture the uncertainties involved in regulatory impact analysis, DOE has determined it is appropriate to include all four sets of SC-CH_4 and SC-N_2O values, as recommended by the IWG. DOE derived values after 2050 using the approach described above for the SC-CO_2.

Table IV.13 Annual SC-CH_4 and SC-N_2O Values from 2021 Interagency Update, 2020–2050 (2020$ per Metric Ton)

Year	SC-CH_4				SC-N_2O			
	Discount Rate and Statistic				Discount Rate and Statistic			
	5%	3%	2.5%	3%	5%	3%	2.5 %	3%
	Average	Average	Average	95th percentile	Average	Average	Average	95th percentile
2020	670	1500	2000	3900	5800	18000	27000	48000
2025	800	1700	2200	4500	6800	21000	30000	54000
2030	940	2000	2500	5200	7800	23000	33000	60000
2035	1100	2200	2800	6000	9000	25000	36000	67000
2040	1300	2500	3100	6700	10000	28000	39000	74000
2045	1500	2800	3500	7500	12000	30000	42000	81000
2050	1700	3100	3800	8200	13000	33000	45000	88000

DOE multiplied the CH_4 and N_2O emissions reduction estimated for each year by the SC-CH_4 and SC-N_2O estimates for that year in each of the cases. DOE adjusted the values to 2022$ using the implicit price deflator for gross domestic product (GDP) from the Bureau of Economic Analysis. To calculate a present value of the stream of monetary values, DOE discounted the values in each of the cases using the specific discount rate that had been used to obtain the SC-CH_4 and SC-N_2O estimates in each case.

2. Monetization of Other Emissions Impacts

For the NOPR, DOE estimated the monetized value of NO_X and SO_2 emissions reductions from electricity generation using the latest benefit-per-ton estimates for that sector from the EPA's Benefits Mapping and Analysis Program.[148] DOE used EPA's values for $PM_{2.5}$-related benefits associated with NO_X and SO_2 and for ozone-related benefits associated with NO_X for 2025, 2030, and 2040, calculated with discount rates of 3 percent and 7 percent. DOE used linear interpolation to define values for the years not

[148] *Estimating the Benefit per Ton of Reducing PM2.5 Precursors from 17 Sectors, February 2018* (Available at www.epa.gov/benmap/estimating-benefit-ton-reducing-directly-emitted-pm25-pm25-precursors-and-ozone-precursors) (Last accessed May 3, 2023).

given in the 2025 to 2040 period; for years beyond 2040, the values are held constant. DOE combined the EPA regional benefit per ton estimates with regional information on electricity consumption and emissions from *AEO 2023* to define weighted-average national values for NO_X and SO_2 (see appendix 14B of the NOPR TSD).

DOE also estimated the monetized value of NO_X and SO_2 emissions reductions from site use of natural gas in consumer boilers using benefit-per-ton estimates from the EPA's Benefits Mapping and Analysis Program.[149] Although none of the sectors covered by EPA refers specifically to residential and commercial buildings, the sector called "area sources" would be a reasonable proxy for residential and commercial buildings.[150] The EPA document provides high and low estimates for 2025 and 2030 at 3- and 7-percent discount rates.[151] DOE used the same linear interpolation and extrapolation as it did with the values for electricity generation.

DOE multiplied the site emissions reduction (in tons) in each year by the associated $/ton values, and then discounted each series using discount rates of 3 percent and 7 percent as appropriate.

[149] *Estimating the Benefit per Ton of Reducing PM2.5 and Ozone Precursors from 21 Sectors, April 2023* (Available at www.epa.gov/benmap/estimating-benefit-ton-reducing-directly-emitted-pm25-pm25-precursors-and-ozone-precursors) (Last accessed May 3, 2023).
[150] "Area sources" represents all emission sources for which States do not have exact (point) locations in their emissions inventories. Because exact locations would tend to be associated with larger sources, "area sources" would be fairly representative of small, dispersed sources like homes and businesses.
[151] "Area sources" are a category in the 2018 document from EPA, but are not used in the latest document cited above. See: *www.epa.gov/sites/default/files/2018-02/documents/sourceapportionmentbpttsd_2018.pdf.*

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 *AEO 2023*. 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 *AEO 2023* Reference case and various side cases. Details of the methodology are provided in the appendices to chapters 13 and 15 of the NOPR 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.

DOE notes that the utility impact analysis as applied to electric utilities only estimates the change to capacity and generation as a result of a standard, as modeled in NEMS, and there is no gas utility analog. DOE further notes that the impact to natural gas utility sales is equivalent to the natural gas saved by the proposed standard and includes those results in chapter 15 of the NOPR TSD

N. Employment Impact Analysis

DOE considers employment impacts in the domestic economy as one factor in selecting a proposed standard. Employment impacts from new or amended energy conservation standards include both direct and indirect impacts. Direct employment impacts are any changes in the number of employees of manufacturers of the products subject to standards. The MIA addresses those impacts. Indirect employment impacts are changes in national employment that occur due to the shift in expenditures and capital investment caused by the purchase and operation of more-efficient appliances. Indirect employment impacts from standards consist of the net jobs created or eliminated in the national economy, other than in the manufacturing sector being regulated, caused by: (1) reduced spending by consumers on energy; (2) reduced spending on new energy supply by the utility industry; (3) increased consumer spending on the products to which the new standards apply and other goods and services, and (4) the effects of those three factors throughout the economy.

One method for assessing the possible effects on the demand for labor of such shifts in economic activity is to compare sector employment statistics developed by the Labor Department's Bureau of Labor Statistics (BLS). BLS regularly publishes its estimates of the number of jobs per million dollars of economic activity in different sectors of the economy, as well as the jobs created elsewhere in the economy by this same economic activity. Data from BLS indicate that expenditures in the utility sector generally create fewer jobs (both directly and indirectly) than expenditures in other sectors of the economy.[152] There are many reasons for these differences, including wage differences and the fact that the utility sector is more capital-intensive and less labor-intensive than other sectors. Energy conservation standards have the effect of reducing consumer utility bills. Because reduced consumer expenditures for energy likely lead to increased expenditures in other sectors of the economy, the general effect of efficiency standards is to shift economic activity from a less labor-intensive sector (*i.e.*, the utility sector) to more labor-intensive sectors (*e.g.*, the retail and service sectors). Thus, the BLS data suggest that net national employment may increase due to shifts in economic activity resulting from energy conservation standards.

DOE estimated indirect national employment impacts for the standard levels considered in this NOPR using an input/output model of the U.S. economy called Impact of Sector Energy Technologies version 4 (ImSET).[153] 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.

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[152] *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: *searchworks.stanford.edu/view/8436340*) (Last accessed Jan. 3, 2023).
[153] 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 Guide* (2015) Pacific Northwest National Laboratory: Richland, WA. PNNL-24563.

DOE notes that ImSET is not a general equilibrium forecasting model, and that there are uncertainties involved in projecting employment impacts, especially changes in the later years of the analysis. Because ImSET does not incorporate price changes, the employment effects predicted by ImSET may over-estimate actual job impacts over the long run for this rule. Therefore, DOE used ImSET only to generate results for near-term timeframes (2030-2035), where these uncertainties are reduced. For more details on the employment impact analysis, see chapter 16 of the NOPR TSD.

V. Analytical Results and Conclusions

The following section addresses the results from DOE's analyses with respect to the considered energy conservation standards for consumer boilers. It addresses the TSLs examined by DOE, the projected impacts of each of these levels if adopted as energy conservation standards for consumer boilers, and the standards levels that DOE is proposing to adopt in this NOPR. Additional details regarding DOE's analyses are contained in the NOPR TSD supporting this document.

A. Trial Standard Levels

In general, DOE typically evaluates potential new or amended standards for products and equipment by grouping individual efficiency levels for each class into TSLs. Use of TSLs allows DOE to identify and consider manufacturer cost interactions between the product classes, to the extent that there are such interactions, and market cross-elasticity from consumer purchasing decisions that may change when different standard levels are set.

In the analysis conducted for this NOPR, DOE analyzed the benefits and burdens of four TSLs for consumer boilers. DOE developed TSLs that combine efficiency levels for each analyzed product class. DOE presents the results for the TSLs in this document, while the results for all efficiency levels that DOE analyzed are in the NOPR TSD.

Table V.1 presents the TSLs and the corresponding efficiency levels that DOE has identified for potential amended energy conservation standards for consumer boilers. TSL 4 represents the maximum technologically feasible ("max-tech") energy efficiency for all product classes. TSL 3 represents the max-tech energy efficiency for oil-fired hot water and steam boilers, condensing technology for gas-fired hot water boilers (but not max-tech), and baseline energy efficiency for gas-fired steam boilers. TSL 3 represents the highest efficiency level for each product class with a positive NPV at both 3 percent and 7 percent discount rate. TSL 2 represents baseline energy efficiency for gas-fired and oil-fired steam boilers and an intermediate energy efficiency for gas-fired and oil-fired hot water boilers. At TSL 2, gas-fired hot water boilers still require condensing technology. TSL 1 represents baseline energy efficiency for gas-fired and oil-fired steam boilers and the minimum improvement in energy efficiency for gas-fired and oil-fired hot water boilers.

Table V.1 Trial Standard Levels for Consumer Boilers

Product Class	Trial Standard Level			
	1	2	3	4
	Efficiency Level			
Gas-fired Hot Water	1	2	3	4
Gas-fired Steam	Baseline	Baseline	Baseline	1
Oil-fired Hot Water	1	1	2	2
Oil-fired Steam	Baseline	Baseline	1	1

DOE constructed the TSLs for this NOPR to include ELs representative of ELs with similar characteristics (*i.e.*, using similar technologies and/or efficiencies, and having roughly comparable equipment availability). The use of representative ELs provided for greater distinction between the TSLs. While representative ELs were included in the TSLs, DOE considered all efficiency levels as part of its analysis. [154]

B. Economic Justification and Energy Savings

1. Economic Impacts on Individual Consumers

DOE analyzed the economic impacts on consumer boiler 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

[154] Efficiency levels that were analyzed for this NOPR are discussed in section IV.C.1 of this document. Results by efficiency level are presented in chapters 8, 10, and 12 of the NOPR TSD.

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 NOPR TSD provides detailed information on the LCC and PBP analyses.

Table V.2 through Table V.9 show the LCC and PBP results for the TSLs considered for each product class. In the first of each pair of tables, the simple payback is measured relative to the baseline product. In the second table, 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. Those who already purchase a product with efficiency at or above a given TSL are not affected. Consumers for whom the LCC increases at a given TSL experience a net cost.

Table V.2 Average LCC and PBP Results for Gas-fired Hot Water Boilers

TSL	Efficiency Level	Average Costs (*2022$*)				Simple Payback (*years*)	Average Lifetime (*years*)
		Installed Cost	First Year's Operating Cost	Lifetime Operating Cost	LCC		
--	Baseline	6,214	1,344	22,808	29,023	--	26.9
1	1	6,483	1,335	22,659	29,141	29.2	26.9
2	2	6,482	1,265	21,676	28,159	3.4	26.9
3	3	6,543	1,221	20,956	27,499	2.7	26.9
4	4	7,506	1,214	20,842	28,348	9.9	26.9

Note: The results for each TSL are calculated assuming that all consumers use products at that efficiency level. The PBP is measured relative to the baseline product.

Table V.3 Average LCC Savings Relative to the No-New-Standards Case for Gas-fired Hot Water Boilers

TSL	Efficiency Level	Life-Cycle Cost Savings	
		Average LCC Savings* (*2022$*)	Percentage of Consumers that Experience Net Cost
1	1	(193)	11
2	2	275	13
3	3	768	11
4	4	(526)	78

* The savings represent the average LCC for affected consumers.
Note: Parentheses indicate negative (-) values.

Table V.4 Average LCC and PBP Results for Gas-fired Steam Boilers

TSL	Efficiency Level	Average Costs (*2022$*)				Simple Payback (*years*)	Average Lifetime (*years*)
		Installed Cost	First Year's Operating Cost	Lifetime Operating Cost	LCC		
1,2,3	Baseline	6,008	1,078	16,872	22,881	--	23.7
4	1	6,192	1,069	16,738	22,930	20.4	23.7

Note: The results for each TSL are calculated assuming that all consumers use products at that efficiency level. The PBP is measured relative to the baseline product.

Table V.5 Average LCC Savings Relative to the No-New-Standards Case for Gas-fired Steam Boilers

TSL	Efficiency Level	Life-Cycle Cost Savings	
		Average LCC Savings* (*2022$*)	Percentage of Consumers that Experience Net Cost
4	1	(53)	56

* The savings represent the average LCC for affected consumers.
Note: Parentheses indicate negative (-) values.

Table V.6 Average LCC and PBP Results for Oil-fired Hot Water Boilers

TSL	Efficiency Level	Average Costs (*2022$*)				Simple Payback (*years*)	Average Lifetime (*years*)
		Installed Cost	First Year's Operating Cost	Lifetime Operating Cost	LCC		
--	Baseline	6,945	2,783	44,601	51,546	--	25.6
1,2	1	7,042	2,753	44,129	51,171	3.3	25.6
3,4	2	7,137	2,724	43,667	50,804	3.3	25.6

Note: The results for each TSL are calculated assuming that all consumers use products at that efficiency level. The PBP is measured relative to the baseline product.

Table V.7 Average LCC Savings Relative to the No-New-Standards Case for Oil-fired Hot Water Boilers

TSL	Efficiency Level	Life-Cycle Cost Savings	
		Average LCC Savings* (*2022$*)	Percentage of Consumers that Experience Net Cost
1,2	1	374	4
3,4	2	666	4

* The savings represent the average LCC for affected consumers.

Table V.8 Average LCC and PBP Results for Oil-fired Steam Boilers

TSL	Efficiency Level	Average Costs (*2022$*)				Simple Payback (*years*)	Average Lifetime (*years*)
		Installed Cost	First Year's Operating Cost	Lifetime Operating Cost	LCC		
1,2	Baseline	6,977	2,726	36,398	43,374	--	19.6
3,4	1	7,202	2,685	35,860	43,062	5.5	19.6

Note: The results for each TSL are calculated assuming that all consumers use products at that efficiency level. The PBP is measured relative to the baseline product.

Table V.9 Average LCC Savings Relative to the No-New-Standards Case for Oil-fired Steam Boilers

TSL	Efficiency Level	Life-Cycle Cost Savings	
		Average LCC Savings* (*2022$*)	Percentage of Consumers that Experience Net Cost
3,4	1	310	14

* The savings represent the average LCC for affected consumers.

b. Consumer Subgroup Analysis

In the consumer subgroup analysis, DOE estimated the impact of the considered TSLs on low-income households, senior-only households, and small business. Table V.10 through Table V.13 compares the average LCC savings and PBP at each efficiency level for the consumer subgroups with similar metrics for the entire consumer sample for each product class of consumer boilers. Chapter 11 of the NOPR TSD presents the complete LCC and PBP results for the subgroups.

Table V.10 Comparison of LCC Savings and PBP for Consumer Subgroups and All Households; Gas-fired Hot Water Boilers

TSL	Low-Income Households	Senior-Only Households	Small Businesses	All Households
Average LCC Savings (*2022$*)				
1	(100)	(267)	(34)	(193)
2	326	190	530	275
3	643	545	777	768
4	(161)	(559)	(541)	(526)
Payback Period (years)				
1	29.1	41.5	12.8	29.2
2	0.8	1.5	1.6	3.4
3	0.9	1.6	1.4	2.7
4	7.4	11.5	4.4	9.9
Consumers with Net Benefit (%)				
1	11	9	5	12
2	13	14	5	14
3	21	25	17	29
4	31	18	8	15
Consumers with Net Cost (%)				
1	7	14	4	11
2	10	14	6	13
3	9	13	6	11
4	34	70	83	78

Table V.11 Comparison of LCC Savings and PBP for Consumer Subgroups and All Households; Gas-fired Steam Boilers

TSL	Low-Income Households	Senior-Only Households	Small Businesses	All Households
Average LCC Savings *(2022$)*				
1,2,3	NA	NA	NA	NA
4	14	(69)	26	(53)
Payback Period (years)				
1,2,3	NA	NA	NA	NA
4	14.7	25.8	7.3	20.4
Consumers with Net Benefit (%)				
1,2,3	NA	NA	NA	NA
4	37	25	64	29
Consumers with Net Cost (%)				
1,2,3	NA	NA	NA	NA
4	25	58	19	56

Table V.12 Comparison of LCC Savings and PBP for Consumer Subgroups and All Households; Oil-fired Hot Water Boilers

TSL	Low-Income Households	Senior-Only Households	Small Businesses	All Households
Average LCC Savings *(2022$)*				
1,2	334	324	438	374
3,4	603	569	771	666
Payback Period (years)				
1,2	1.3	2.9	1.8	3.3
3,4	1.3	2.9	1.8	3.3
Consumers with Net Benefit (%)				
1,2	70	71	61	70
3,4	85	89	74	86
Consumers with Net Cost (%)				
1,2	1	2	15	4
3,4	1	2	19	4

Table V.13 Comparison of LCC Savings and PBP for Consumer Subgroups and All Households; Oil-fired Steam Boilers

TSL	Low-Income Households	Senior-Only Households	Small Businesses	All Households
Average LCC Savings *(2022$)*				
1,2	NA	NA	NA	NA
3,4	279	284	468	310
Payback Period (years)				
1,2	NA	NA	NA	NA
3,4	3.2	4.7	3	5.5
Consumers with Net Benefit (%)				
1,2	NA	NA	NA	NA
3,4	77	83	65	80
Consumers with Net Cost (%)				
1,2	NA	NA	NA	NA
3,4	5	10	30	14

c. Rebuttable Presumption Payback

As discussed in section III.G.2 of this document, EPCA establishes a rebuttable presumption that an energy conservation standard is economically justified if the increased purchase cost for a product that meets the standard is less than three times the value of the first-year energy savings resulting from the standard. In calculating a rebuttable presumption payback period for each of the considered TSLs, DOE used discrete values, and, as required by EPCA, based the energy use calculation on the DOE test procedure for consumer boilers. 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.14 presents the rebuttable-presumption payback periods for the considered TSLs for consumer boilers. While DOE examined the rebuttable-presumption criterion, it assessed whether the standard levels considered for the NOPR are economically justified through a more detailed analysis of the economic impacts of those levels, pursuant to 42 U.S.C. 6295(o)(2)(B)(i), that considers the full range of impacts to the consumer, manufacturer, Nation, and environment. The results of that analysis serve as the basis for DOE to definitively evaluate the economic justification for a potential standard level, thereby supporting or rebutting the results of any preliminary determination of economic justification.

Table V.14 Rebuttable-Presumption Payback Periods

TSL	Gas-fired Hot Water	Gas-fired Steam	Oil-fired Hot Water	Oil-fired Steam
1	20.2	-	2.2	-
2	4.0	-	2.2	-
3	2.7	-	2.2	5.1
4	9.7	13.3	2.2	5.1

2. Economic Impacts on Manufacturers

DOE performed an MIA to estimate the impact of amended energy conservation standards on manufacturers of consumer boilers. The following section describes the expected impacts on manufacturers at each considered TSL. Chapter 12 of the NOPR 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 potential standard. The following tables summarize the estimated financial impacts (represented by changes in INPV) of potential amended energy conservation standards on manufacturers of consumer boilers, as well as the conversion costs that DOE estimates manufacturers of consumer boilers would incur at each TSL. To evaluate the range of cash-flow impacts on the consumer boiler industry, DOE analyzed two scenarios using different assumptions that correspond to the range of anticipated market responses to amended energy conservation standards: (1) the preservation of gross margin percentage scenario; and (2) the preservation of operating profit scenario. These are discussed in further detail in section IV.J.2.d of this document.

The preservation of gross margin percentage scenario applies a "gross margin percentage" of 29 percent for all product classes and all efficiency levels.[155] This scenario assumes that a manufacturer's per-unit dollar profit would increase as MPCs increase in the standards cases and represents the likely upper-bound to industry profitability under potential amended energy conservation standards.

[155] The gross margin percentage of 29 percent is based on a manufacturer markup of 1.41.

The preservation of operating profit scenario reflects manufacturers' concerns about their inability to maintain margins as MPCs increase to reach more-stringent efficiency levels. In this scenario, while manufacturers make the necessary investments required to convert their facilities to produce compliant products, operating profit does not change in absolute dollars and decreases as a percentage of revenue. The preservation of operating profit scenario represents the likely lower (or more severe) bound to financial impacts of potential amended standards on industry.

Each of the modeled scenario's results in a unique set of cash flows and corresponding INPV for each TSL for consumer boiler manufacturers. INPV is the sum of the discounted cash flows to the industry from the base year through the end of the analysis period (2023–2059). 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 figure 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 (*i.e.*, capital conversion costs) and product designs (*i.e.*, product conversion costs) 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 a new or amended 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.

Table V.15 presents the overall estimated industry MIA results at each analyzed TSL. Table V.16, Table V.17, Table V.18, and Table V.19 present the estimated MIA results at each analyzed TSL for gas-fired hot water, gas-fired steam, oil-fired hot water, and oil-fired steam product classes, respectively. See chapter 12 of the NOPR TSD for a discussion of cash-flow analysis results by product class.

Table V.15 Manufacturer Impact Analysis of Consumer Boiler Industry Results

	Unit	No-New-Standards Case	TSL 1	TSL 2	TSL 3	TSL 4
INPV	*2022$ millions*	532.0	514.1 to 517.1	487.0 to 504.8	469.7 to 491.2	411.9 to 527.6
Change in INPV*	*2022$ millions*		(17.9) to (14.9)	(45.0) to (27.2)	(62.2) to (40.7)	(120.0) to (4.3)
	%	-	(3.4) to (2.8)	(8.5) to (5.1)	(11.7) to (7.7)	(22.6) to (0.8)
Free Cash Flow (2029)*	*2022$ millions*	47.2	34.6	17.4	5.5	(22.2)
Change in Free Cash Flow (2029)*	*%*	-	(26.7)	(63.2)	(88.4)	(147.0)
Capital Conversion Costs	*2022$ millions*	-	12.7	55.1	74.5	98.6
Product Conversion Costs	*2022$ millions*	-	19.6	14.4	23.5	71.5
Total Conversion Costs	*2022$ millions*	-	32.3	69.5	98.0	170.1

*Parentheses denote negative (-) values.

Table V.16 Manufacturer Impact Analysis of Gas-fired Hot Water Consumer Boiler Industry Results

	Unit	No-New-Standards Case	TSL 1	TSL 2	TSL 3	TSL 4
INPV	*2022$ millions*	409.4	399.1 to 401.5	371.9 to 389.0	364.6 to 384.4	316.7 to 428.9
Change in INPV*	*2022$ millions*	-	(10.3) to (8.0)	(37.5) to (20.4)	(44.9) to (25.0)	(92.8) to 19.5
	%	-	(2.5) to (1.9)	(9.2) to (5.0)	(11.0) to (6.1)	(22.7) to 4.8
Capital Conversion Costs	*2022$ millions*	-	8.1	50.5	62.2	77.9
Product Conversion Costs	*2022$ millions*	-	9.9	4.7	3.1	39.5
Total Conversion Costs	*2022$ millions*	-	17.9	55.1	65.2	117.4

*Parentheses denote negative (-) values.

Table V.17 Manufacturer Impact Analysis of Gas-fired Steam Consumer Boiler Industry Results

	Unit	No-New-Standards Case	TSL 1	TSL 2	TSL 3	TSL 4
INPV	*2022$ millions*	41.7	41.7	41.7	41.7	30.8 to 32.5
Change in INPV*	*2022$ millions*	-	-	-	-	(10.9) to (9.3)
	%	-	-	-	-	(26.2) to (22.2)
Capital Conversion Costs	*2022$ millions*	-	-	-	-	8.4
Product Conversion Costs	*2022$ millions*	-	-	-	-	11.5
Total Conversion Costs	*2022$ millions*	-	-	-	-	19.9

*Parentheses denote negative (-) values.

Table V.18 Manufacturer Impact Analysis of Oil-fired Hot Water Consumer Boiler Industry Results

	Unit	No-New-Standards Case	TSL 1	TSL 2	TSL 3	TSL 4
INPV	*2022$ millions*	73.5	65.9 to 66.6	65.9 to 66.6	60.0 to 61.4	60.0 to 61.4
Change in INPV*	*2022$ millions*	-	(7.6) to (6.9)	(7.6) to (6.9)	(13.6) to (12.1)	(13.6) to (12.1)
	%	-	(10.3) to (9.4)	(10.3) to (9.4)	(18.4) to (16.4)	(18.4) to (16.4)
Capital Conversion Costs	*2022$ millions*	-	4.7	4.7	8.4	8.4
Product Conversion Costs	*2022$ millions*	-	9.7	9.7	17.2	17.2
Total Conversion Costs	*2022$ millions*	-	14.4	14.4	25.6	25.6

*Parentheses denote negative (-) values.

Table V.19 Manufacturer Impact Analysis of Oil-fired Steam Consumer Boiler Industry Results

	Unit	No-New-Standards Case	TSL 1	TSL 2	TSL 3	TSL 4
INPV	*2022$ millions*	7.5	7.5	7.5	3.4 to 3.6	3.4 to 3.6
Change in INPV*	*2022$ millions*	-	-	-	(4.1) to (4.0)	(4.1) to (4.0)
	%	-	-	-	(54.6) to (52.7)	(54.6) to (52.7)
Capital Conversion Costs	*2022$ millions*	-	-	-	3.9	3.9
Product Conversion Costs	*2022$ millions*	-	-	-	3.3	3.3
Total Conversion Costs	*2022$ millions*	-	-	-	7.2	7.2

*Parentheses denote negative (-) values.

At TSL 4, the standard represents the max-tech efficiencies for all boiler product classes. At this level, DOE estimates the change in INPV would range from -22.6 to -0.8 percent. At TSL 4, free cash flow is estimated to decrease to -$22.0 million, which represents a decrease of approximately 147.0 percent compared to the no-new-standards case value of $47.2 million in the year 2029, the year before the anticipated compliance date. DOE’s shipments analysis estimates approximately 10 percent of current shipments meet this level. DOE estimates capital conversion costs of $98.6 million and product conversion of costs of $71.5 million. Industry conversion costs total $170.1 million.

At TSL 4, the large conversion costs result in a free cash flow dropping below zero in the years before the standards year. The negative free cash flow calculation indicates manufacturers may need to access cash reserves or outside capital to finance conversion efforts.

At TSL 4, the shipment-weighted average MPC for all consumer boilers is expected to increase by 41.4 percent relative to the no-new-standards case shipment-weighted average MPC for all consumer boilers in 2030. In the preservation of gross margin percentage scenario (in which manufacturers can fully pass along this cost increase), the increase in cashflow from the higher MSP is outweighed by the $170.1 million in conversion costs, causing a slightly negative change in INPV at TSL 4 under this scenario. Under the preservation of operating profit scenario, the manufacturer markup decreases in 2031, the year after the anticipated compliance date. This reduction in the manufacturer markup and the $170.1 million in conversion costs incurred by manufacturers cause a large negative change in INPV at TSL 4 under the preservation of operating profit scenario.

The design options analyzed at TSL 4 for gas-fired hot water boilers, which accounts for approximately 75 percent of industry shipments, included implementing a condensing stainless-steel heat exchanger with increased heat exchanger surface area and improvements in geometry as compared to the designs analyzed at TSL 3 (95 percent AFUE) and a premix, modulating burner.

Out of the 24 gas-fired hot water boiler OEMs, only six OEMs offer models that meet the efficiencies required by TSL 4. At this level, all gas-fired hot water boilers must transition to the max-tech condensing technology. This is a significant technological shift and may be challenging for many manufacturers. Less than 5 percent of gas-fired hot water model listings can meet the 96-percent AFUE required. At this level, DOE estimates the change in INPV for the gas-fired hot water boiler industry would range from -2.5 to 1.9 percent.

With approximately 95 percent of all model offerings currently on the market rendered obsolete, all 24 manufacturers would need to re-evaluate and redesign their portfolio of gas-fired hot water product offerings. Many OEMs that have extensive condensing gas-fired hot water product offerings do not have any models that can meet max-tech. Even OEMs that offer some max-tech models today would need to allocate extensive technical resources to provide max-tech offerings across the full range of capacities to serve their customers. Manufacturers that are heavily invested in the non-condensing market would likely need to re-orient their role in the market and determine how to compete in a marketplace where there is only one efficiency level.

Traditionally, manufacturers have designed their product lines to support a range of models with varying input capacities, and the efficiency has varied between models within the line. In reviewing available models, DOE found that manufacturers generally only have one or two input capacities optimized to achieve 96-percent AFUE within each product line, while the remaining input capacities are at a lower AFUE. This suggests that manufacturers may have to individually redesign each model within product lines to ensure all models can achieve the max-tech level. A model-by-model redesign would necessitate a significant increase in design effort for manufacturers. Additionally, in confidential interviews, some manufacturers who source condensing heat exchangers expressed concern that the relatively lower shipment volumes of boilers in the U.S. market – compared to international markets for boilers – could make it difficult to find suppliers willing to produce heat exchanger designs that would allow all models within their gas-fired hot water product lines to meet 96-percent AFUE, as each heat exchanger design would need to be optimized for a given input capacity. DOE estimates gas-fired hot water boiler product conversion costs of $3.1 million. The push toward new product designs would also require changes to the manufacturing facilities. Manufacturers would need to extend or add additional assembly lines to accommodate the growth in condensing gas-fired hot water boiler sales. Furthermore, manufacturers that are heavily invested in the non-condensing market would likely have need to make the most significant capital investments, such as new production lines and updates to the factory floor. DOE estimates gas-fired hot water boiler capital conversion costs of $65.2 million.

For the remaining product classes (gas-fired steam, oil-fired hot water, oil-fired steam), the design options analyzed mainly included increasing heat exchanger surface area relative to lower efficiency levels. The max-tech efficiency level at TSL 4 for these three product classes does not require a shift to condensing designs and does not dramatically alter the manufacturing process. Gas-fired steam shipments account for approximately 10 percent of current industry shipments. Oil-fired hot water shipments account for approximately 14 percent of current industry shipments. Oil-fired steam shipments account for approximately 1 percent of current industry shipments.

All four gas-fired steam boiler OEMs offer some models that meet the max-tech efficiencies. However, only 8 percent of gas-fired steam model listings meet the efficiencies required by TSL 4. At this level, DOE estimates the change in INPV for the gas-fired steam boiler industry would range from -26.2 percent and -22.2 percent. DOE estimates gas-fired steam boiler capital conversion costs of $8.4 million and gas-fired steam boiler product conversion of costs of $11.5 million.

Out of the 11 oil-fired hot water boiler OEMs, only two OEMs offer models that meet the max-tech efficiencies. Approximately 3 percent of oil-fired hot water model listings currently meet the TSL 4 efficiencies. At this level, DOE estimates the change in INPV for the oil-fired hot water boiler industry would range from -18.4 percent and -16.4 percent. DOE estimates oil-fired hot water boiler capital conversion costs of $8.4 million and oil-fired hot water boiler product conversion of costs of $17.2 million.

Out of the four oil-fired steam boiler OEMs, two OEMs offer models that meet the max-tech efficiencies. Approximately 22 percent of oil-fired steam model listings currently meet the TSL 4 efficiencies. At this level, DOE estimates the change in INPV for the oil-fired steam industry would range from -54.6 percent and -52.7 percent. DOE estimates oil-fired steam boiler capital conversion costs of $3.9 million and oil-fired steam boiler product conversion of costs of $3.3 million.

The design options available to increase the efficiency of gas-fired steam, oil-fired hot water, and oil-fired steam boilers are similar. Manufacturers may be able to meet max-tech efficiency for some models by adding additional heat exchanger sections. However, where additional sections are not sufficient, manufacturers may need to invest in the more time-intensive process of redesigning of the heat exchanger and in new castings and tooling to achieve max-tech efficiencies.

At TSL 3, the standard represents EL 3 for gas-fired hot water boilers, baseline efficiency for gas-fired steam boilers, EL 2 for oil-fired hot water boilers, and EL 1 for oil-fired steam boiler. At this level, DOE estimates the change in INPV would range from -11.7 to -7.7 percent. At TSL 3, free cash flow is estimated to decrease to -$5.5 million, which represents a decrease of approximately 88.4 percent compared to the no-new-standards case value of $47.2 million in the year 2029, the year before the anticipated compliance year. DOE's shipments analysis estimates approximately 57 percent of current shipments meet this level.

The decrease in industry conversion costs compared to TSL 4 is entirely driven by the lower efficiencies required for gas-fired hot water and gas-fired steam boilers. As with TSL 4, manufacturers heavily invested in non-condensing gas-fired hot water boilers would need to develop or expand their condensing production capacity. However, unlike TSL 4, most manufacturers currently offer products that meet the 95 percent AFUE required at this TSL. DOE estimates capital conversion costs of $74.5 million and product conversion of costs of $23.5 million. Conversion costs total $98.0 million.

At TSL 3, the large conversion costs result in a free cash flow dropping below zero in the years before the standards year. The negative free cash flow calculation indicates manufacturers may need to access cash reserves or outside capital to finance conversion efforts.

At TSL 3, the shipment-weighted average MPC for all consumer boilers is expected to increase by 8.0 percent relative to the no-new-standards case shipment-weighted average MPC for all consumer boilers in 2030. In the preservation of gross margin percentage scenario, the increase in cashflow from the higher MSP is outweighed by the $98.0 million in conversion costs, causing a negative change in INPV at TSL 3 under this scenario. Under the preservation of operating profit scenario, the manufacturer markup decreases in 2031, the year after the anticipated compliance date. This reduction in the manufacturer markup and the $98.0 million in conversion costs incurred by manufacturers cause a negative change in INPV at TSL 3 under the preservation of operating profit scenario.

The design options analyzed at TSL 3 for gas-fired hot water boilers included implementing a condensing stainless-steel heat exchanger with a premix modulating burner. Out of the 24 gas-fired hot water boiler OEMs, 18 OEMs offer models that meet the efficiencies required by TSL 3 (95-percent AFUE). Approximately 40 percent of gas-fired hot water model listings currently meet TSL 3 efficiencies. At this level, DOE estimates the change in INPV for the gas-fired hot water industry would range from -11.0 percent and -6.1 percent. DOE estimates gas-fired hot water boiler capital conversion costs of $62.2 million and gas-fired hot water boiler product conversion of costs of $3.1 million. As with TSL 4, manufacturers heavily invested in non-condensing gas-fired hot water boilers would need to develop or expand their condensing production capacity, which would necessitate new production lines and updates to the factory floor. However, unlike TSL 4, most manufacturers currently offer products that meet the 95-percent AFUE required. Additionally, TSL 3 reduces the need to redesign by optimizing design at the individual model level to meet amended standards.

For gas-fired steam boilers, TSL 3 corresponds to the baseline efficiency level (82 percent AFUE). As a result, when evaluating this product class in isolation, DOE expects that the gas-fired steam industry would incur zero conversion costs. For oil-fired hot water and oil-fired steam boilers, the efficiency level required at TSL 3 is the same as TSL 4. As a result, DOE expects that the estimated changes in INPV and associated capital and product conversion costs for oil-fired hot water and oil-fired steam boilers at TSL 3 would be the same as TSL 4.

At TSL 2, the standard represents EL 2 for gas-fired hot water boilers, baseline efficiency for gas-fired steam boilers, EL 1 for oil-fired hot water boilers, and baseline efficiency for oil-fired steam boilers. At this level, DOE estimates the change in INPV would range from -8.5 to -5.1 percent. At TSL 2, free cash flow is estimated to decrease to $17.4 million, which represents a decrease of approximately 63.2 percent compared to the no-new-standards case value of $47.2 million in the year 2029, the year before the anticipated compliance date. DOE's shipments analysis estimates approximately 70 percent of current shipments meet this level.

The decrease in conversion costs compared to TSL 3 is entirely driven by the lower efficiencies required for gas-fired hot water, oil-fired hot water, and oil-fired steam boilers, which all together account for 90 percent of current industry shipments. As with TSL 3 and TSL 4, manufacturers heavily invested in non-condensing gas-fired hot water boilers would need to develop or expand their condensing production capacity. However, at TSL 2, more manufacturers currently offer products that meet the 90-percent AFUE required. DOE estimates capital conversion costs of $55.1 million and product conversion of costs of $14.4 million. Conversion costs total $69.5 million.

At TSL 2, the shipment-weighted average MPC for all consumer boilers is expected to increase by 6.8 percent relative to the no-new-standards case shipment-weighted average MPC for all consumer boilers in 2030. In the preservation of gross margin percentage scenario, the increase in cashflow from the higher MSP is slightly outweighed by the $69.5 million in conversion costs, causing a negative change in INPV at TSL 2 under this scenario. Under the preservation of operating profit scenario, the manufacturer markup decreases in 2031, the year after the anticipated compliance date. This reduction in the manufacturer markup and the $69.5 million in conversion costs incurred by manufacturers cause a negative change in INPV at TSL 2 under the preservation of operating profit scenario.

The design options analyzed at TSL 2 for gas-fired hot water boilers included implementing a condensing cast aluminum or stainless-steel heat exchanger and modulating burner. Out of the 24 gas-fired hot water boiler OEMs, 21 OEMs offer models that meet the efficiencies required by TSL 2. Approximately 54 percent of gas-fired hot water model listings currently meet TSL 2 efficiencies. At this level, DOE estimates the change in INPV for the gas-fired hot water industry would range from -9.2 percent to -5.0 percent. DOE estimates gas-fired hot water boiler capital conversion costs of $50.5 million and gas-fired hot water boiler product conversion of costs of $4.7 million. As with TSL 3 and TSL 4, manufacturers heavily invested in non-condensing gas-fired hot water boilers would need to develop or expand their condensing production capacity. However, at TSL 2, more manufacturers currently offer products that meet the 90-percent AFUE required. Product conversion costs would be driven by the development and testing necessary to develop compliant, cost-competitive products.

For gas-fired steam boilers and oil-fired steam boilers, TSL 2 corresponds to the baseline efficiency levels (82 percent AFUE and 85 percent AFUE, respectively). As a result, when evaluating these product classes in isolation, DOE expects that the gas-fired steam and oil-fired steam industries would incur zero conversion costs.

For oil-fired hot water boilers, TSL 2 corresponds to EL 1 (87 percent AFUE). The design options analyzed for oil-fired hot water boilers included increasing the heat exchanger surface area beyond what was analyzed at baseline but less than what was analyzed at max-tech (EL 2). Out of the 11 oil-fired hot water boiler OEMs, 10 OEMs offer models that meet the efficiencies required. Approximately 44 percent of oil-fired hot water model listings currently meet TSL 2 efficiencies. At this level, DOE estimates the change in INPV for the oil-fired hot water industry would range from -10.3 percent to -9.4 percent. DOE estimates oil-fired hot water boiler capital conversion costs of $4.7 million and oil-fired hot water boiler product conversion of costs of $9.7 million. DOE expects that some manufacturers would need to invest in new casting designs and tooling to meet TSL 2 efficiencies.

At TSL 1, the standard represents EL 1 for gas-fired hot water boilers, baseline efficiency for gas-fired steam boilers, EL 1 for oil-fired hot water boilers, and baseline efficiency for oil-fired steam boilers. At this level, DOE estimates the change in INPV would range from -3.4 to -2.8 percent. At TSL 1, free cash flow is estimated to decrease to $34.6 million, which represents a decrease of approximately 26.7 percent compared to the no-new-standards case value of $47.2 million in the year 2029, the year before the anticipated compliance date. DOE's shipments analysis estimates approximately 73 percent of current shipments meet this level.

The decrease in conversion costs compared to TSL 2 is entirely driven by the lower efficiency required for gas-fired hot water boilers, which accounts for 75 percent of current industry shipments. DOE estimates industry capital conversion costs of $12.7 million and product conversion of costs of $19.6 million. Conversion costs total $32.3 million.

At TSL 1, the shipment-weighted average MPC for all consumer boilers is expected to increase by 1.2 percent relative to the no-new-standards case shipment-weighted average MPC for all consumer boilers in 2030. In the preservation of gross margin percentage scenario, the increase in cashflow from the higher MSP is slightly outweighed by the $32.3 million in conversion costs, causing a slightly negative change in INPV at TSL 1 under this scenario. Under the preservation of operating profit scenario, the manufacturer markup decreases in 2031, the year after the anticipated compliance date. This reduction in the manufacturer markup and the $32.3 million in conversion costs incurred by manufacturers cause a slightly negative change in INPV at TSL 1 under the preservation of operating profit scenario.

The design options analyzed for gas-fired hot water boilers included increasing heat exchanger surface area beyond what was analyzed at the baseline efficiency. For gas-fired hot water boilers, TSL 1 corresponds to EL 1 (85 percent AFUE). Out of the 24 gas-fired hot water OEMs, 23 offer models that meet the TSL 1 efficiencies. Approximately 67 percent of gas-fired hot water model listings currently meet TSL 1 efficiencies. At this level, DOE estimates the change in INPV for the gas-fired hot water industry would range from -2.5 percent to -1.9 percent. DOE estimates gas-fired hot water boiler capital conversion costs of $8.1 million and gas-fired hot water boiler product conversion of costs of $9.9 million.

For gas-fired steam boilers and oil-fired steam boilers, TSL 1 corresponds to the baseline efficiency levels (82 percent AFUE and 85 percent AFUE, respectively). As a result, when evaluating these product classes in isolation, DOE expects that the gas-fired steam and oil-fired steam industries would incur zero conversion costs.

For oil-fired hot water boilers, the efficiency level required at TSL 1 is the same as TSL 2. As a result, DOE expects that the estimated changes in INPV and associated capital and product conversion costs for oil-fired hot water boilers at TSL 1 would be the same as TSL 2.

DOE seeks comments, information, and data on the capital conversion costs and product conversion costs estimated for each TSL.

b. Direct Impacts on Employment

To quantitatively assess the potential impacts of amended energy conservation standards on direct employment in the consumer boiler 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 (*i.e.*, TSLs) during the analysis period. DOE calculated these values using statistical data from the 2021 *ASM*,[156] BLS employee compensation data,[157] results of the engineering analysis, DOE's CCD, and manufacturer interviews.

Labor expenditures related to product manufacturing depend on the labor intensity of the product, the sales volume, and an assumption that wages remain fixed in real terms over time. The labor expenditures in each year are calculated by multiplying the total MPCs by the labor percentage of the MPCs. The labor expenditures in the GRIM were then converted to production employment levels by dividing production labor expenditures by the average fully-burdened wage multiplied by the average number of hours worked per year per production worker. To do this, DOE relied on the *ASM* inputs: Production Workers Annual Wages, Production Workers Annual Hours, Production Workers for Pay Period, and Number of Employees. DOE also relied on the BLS employee compensation data to determine the fully-burdened wage ratio. The fully-

[156] U.S. Census Bureau, *Annual Survey of Manufactures*, "Summary Statistics for Industry Groups and Industries in the U.S (2021)," (Available at: *www.census.gov/data/tables/time-series/econ/asm/2018-2021-asm.html*) (Last accessed Feb. 14, 2023).
[157] 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 Feb. 14, 2023).

burdened wage ratio factors in paid leave, supplemental pay, insurance, retirement and savings, and legally-required benefits.

The number of production employees is then multiplied by the U.S. labor percentage to convert production employment to domestic production employment. The U.S. labor percentage represents the industry fraction of domestic manufacturing production capacity for the covered product. This value is derived from manufacturer interviews, product database analysis, and publicly-available information. Research indicates that over 90 percent of non-condensing gas-fired hot water, gas-fired steam, oil-fired hot water, and oil-fired steam boilers are manufactured in the United States. Research indicates that approximately 60 percent of condensing gas-fired hot water boilers are manufactured in the United States. Therefore, overall, DOE estimates that 75 percent of covered consumer boilers are produced domestically.

In addition to where the boiler is physically assembled, DOE considers whether the principal components (*e.g.*, the heat exchanger) are produced in-house and in the United States. For non-condensing gas-fired hot water, gas-fired steam, oil-fired hot water, and oil-fired steam boilers, DOE estimates that over 90 percent of the heat exchangers are produced in the United States. However, DOE determined that nearly all condensing gas-fired hot water heat exchangers are purchased from overseas manufacturers. Therefore, the domestic labor associated with condensing heat exchangers is significantly less than the domestic labor associated with non-condensing heat exchangers.

The domestic production employees estimate covers production line workers, including line supervisors, who are directly involved in fabricating and assembling products within the OEM facility. Workers performing services that are closely associated with production operations, such as materials handling tasks using forklifts, are also included as production labor.[158] DOE's estimates only account for production workers who manufacture the specific products covered by this proposed rulemaking.

Non-production workers account for the remainder of the direct employment figure. The non-production employees estimate covers domestic workers who are not directly involved in the production process, such as sales, engineering, human resources, and management.[159] Using the number of domestic production workers calculated above, non-production domestic employees are extrapolated by multiplying the ratio of non-production workers in the industry compared to production employees. DOE assumes that this employee distribution ratio remains constant between the no-new-standards case and standards cases.

Using the GRIM, DOE estimates that in the absence of new energy conservation standards, there would be 526 domestic workers for consumer boilers in 2030. Table V.20 shows the range of the impacts of energy conservation standards on U.S. manufacturing employment in the consumer boiler industry. The following discussion

[158] U.S. Census Bureau's *Annual Survey of Manufactures*, "Definitions and Instructions for the Annual Survey of Manufactures, MA-10000" (Available at: *www2.census.gov/programs-surveys/asm/technical-documentation/questionnaire/2021/instructions/MA_10000_Instructions.pdf*) (Last accessed March 5, 2023).
[159] *Id.*

provides a qualitative evaluation of the range of potential impacts presented in Table V.20.

Table V.20 Domestic Direct Employment Impacts for Consumer Boiler Manufacturers in 2030

	No-New-Standards Case	TSL 1	TSL 2	TSL 3	TSL 4
Direct Employment (Domestic Production Workers + Domestic Non-Production Workers)	526	521	453 to 511	450 to 497	464 to 541
Potential Changes in Direct Employment Workers*	-	(5)	(15) to (73)	(29) to (76)	15 to (62)

*DOE presents a range of potential direct employment impacts.
Note: Parentheses indicate negative (-) values.

The direct employment impacts shown in Table V.20 represent the potential domestic employment changes that could result following the compliance date of amended energy conservation standards for the consumer boilers covered in this proposal. The upper bound estimate corresponds to a change in the number of domestic workers that results from amended energy conservation standards if manufacturers continue to produce the same scope of covered products within the United States after compliance is required. Under a condensing gas-fired hot water boiler standard (*i.e.*, TSL 2 through TSL 4), manufacturers would likely shift away from in-house production of heat exchangers, which results in a decrease in direct employment at TSL 2 and TSL 3. TSL 4 shows potential positive impacts on domestic direct employment levels as max-tech boilers (96-percent AFUE) are more complex to manufacturer and require significant additional production labor.

Manufacturers could choose to relocate production facilities outside of the United States where conversion costs and production costs are lower; however, DOE does not expect manufacturers to move production to foreign locations as a result of amended energy conservation standards due to shipping considerations. Alternatively, some manufacturers could choose not to make the necessary investments to meet the amended energy conservation standards across all product classes. To avoid underestimating the potential job losses that could result from an amended energy conservation standard, DOE's lower bound scenario assumes domestic manufacturers do not expand their condensing production capacity in the standards cases and are only able to maintain current sales levels of condensing boilers in the standards cases.

At TSLs that do not require condensing technology (*i.e.*, TSL 1), DOE does not expect that there would be significant changes in production employment as a direct result of amended conservation standards, as manufacturers would likely continue to produce a similar scope of non-condensing heat exchangers and consumer boilers in the United States. However, under a condensing standard (*i.e.*, TSL 2 through TSL 4), manufacturers would shift from sourcing or producing non-condensing heat exchangers for gas-fired hot water boilers, which are typically manufactured in U.S. facilities, to sourcing condensing heat exchangers that are typically manufactured in foreign countries.

Additional detail on the analysis of direct employment can be found in chapter 12 of the NOPR TSD. DOE notes that the direct employment impacts discussed in this section are independent of the indirect employment impacts from the broader U.S. economy, which are documented in chapter 16 of the NOPR TSD.

DOE seeks comments, information, and data on the potential direct employment impacts estimated for each TSL.

c. Impacts on Manufacturing Capacity

Nearly all consumer boiler OEMs currently offer some gas-fired hot water boiler models that meet the TSL 3 condensing level proposed (95-percent AFUE). At TSL 3, 19 out of the 25 gas-fired hot water boiler OEMs currently offer models that meet the proposed level or required efficiency. DOE interviewed manufacturers representing approximately 45 percent of industry shipments. In interviews, manufacturers heavily invested in non-condensing gas-fired hot water boilers stated that they would need to expand their condensing production capacity, which would necessitate new production lines and updates to the factory floor. However, most manufacturers would be able to add capacity and adjust product designs in the 5-year period between the announcement year of the amended standard and the compliance year of the amended standard.

At max-tech, only 9 percent of gas-fired hot water boiler shipments currently meet the efficiency required. In interviews, most manufacturers stated that they would likely need to work with component manufacturers to develop new heat exchanger designs to consistently meet the max-tech efficiencies. Some manufacturers expressed concern that the 5-year conversion period would be insufficient to develop a cost-competitive heat exchanger that could reliably achieve 96-percent AFUE.

DOE seeks comment on whether manufacturers expect that manufacturing capacity or engineering resource constraints would limit product availability to consumers in the timeframe of the amended standards compliance date (2030).

d. Impacts on Subgroups of Manufacturers

Using average cost assumptions to develop industry cash-flow estimates may not capture the differential impacts among subgroups of manufacturers. Small manufacturers, niche players, or manufacturers exhibiting a cost structure that differs substantially from the industry average could be affected disproportionately. DOE investigated small businesses as a manufacturer subgroup that could be disproportionally impacted by amended energy conservation standards and could merit additional analysis. DOE also identified OEMs that own cast-iron foundries specializing in consumer boiler castings as a potential manufacturer subgroup that could be adversely impacted by amended energy conservation standards based on the results of the industry characterization.

Small Businesses

DOE analyzes the impacts on small businesses in a separate analysis in section VI.B of this document as part of the Regulatory Flexibility Analysis. In summary, the SBA defines a "small business" as having 500 employees or less for North American Industry Classification System (NAICS) 333414, "Heating Equipment (except Warm Air Furnaces) Manufacturing." Based on this classification, DOE identified three domestic OEMs that qualify as a small business. For a discussion of the impacts on the small business manufacturer subgroup, see the Regulatory Flexibility Analysis in section VI.B of this document and chapter 12 of the NOPR TSD.

Manufacturers That Own Domestic Foundries

In addition to the small business subgroup, DOE identified vertically-integrated OEMs that own domestic foundries specializing in consumer boiler castings as a subgroup that may experience differential impacts under a condensing gas-fired hot water standard (*i.e.*, TSL 2 through TSL 4).

Research indicates that most non-condensing boilers use cast-iron heat exchangers. Based on manufacturer interviews, the engineering analysis, and the database of consumer boilers developed as part of the market assessment, DOE estimates that nearly all non-condensing cast-iron heat exchangers are made in U.S. foundries. Furthermore, DOE understands that nearly all condensing heat exchangers are manufactured overseas. Under a condensing standard, there will be a significant reduction in demand for consumer boiler cast-iron heat exchangers as gas-fired hot water boilers account for approximately 45 percent of the non-condensing consumer boiler shipments.

Most consumer boiler manufacturers currently rely on third-party foundries for their consumer boiler castings. Based on a review of public data and information gathered during confidential interviews, DOE found that most boiler OEMs source their consumer boiler castings from one third-party foundry in Waupaca, Wisconsin. DOE tentatively concluded that this foundry's operations would not be impacted by the reduction in cast-iron heat exchanger production since consumer boilers account for a minimal part of their casting portfolio. However, foundries owned by consumer boiler OEMs typically specialize in consumer and commercial boiler casting and would be impacted by the reduction in cast-iron heat exchanger production. DOE believes that 15 to 25 percent of all consumer boilers are produced by OEMs that own foundry assets. For the purpose of this subgroup analysis, DOE modeled 20 percent of all consumer boilers being manufactured by OEMs that own foundry assets.

In response to the May 2022 Preliminary Analysis, stakeholders asserted that cast-iron foundries producing heat exchangers for non-condensing boilers have large, fixed costs that could no longer be amortized across gas-fired hot water consumer boilers sales under a condensing standard. Stakeholders noted that cast-iron boiler manufacturers, particularly those that own a foundry, could face a range of potential negative impacts of more-stringent consumer boiler standards, including: (1) increases in cast-iron prices in other boiler types; (2) stranded assets; (3) potential job losses associated with foundry operation, casting, and assembly, which could lead to a reduction in domestic manufacturing employment; and (4) possible foundry closures.

DOE used the subgroup analysis GRIM to assess the potential financial impacts of a condensing standard on boiler OEMs with foundries. In its analysis, DOE evaluated the financial viability of these OEMs if the foundries remained operational but at reduced output due to the shift away from cast-iron heat exchangers under a condensing standard for gas-fired hot water consumer boilers. DOE also evaluated potential increases in cast-iron MPCs for gas-fired steam, oil-fired hot water, and oil-fired steam products, reduced profitability for those products, and stranded assets associated with gas-fired hot water products in the subgroup analysis GRIM. Additionally, DOE analyzed potential job losses associated with foundry operation, casting, and assembly in section V.B.2.b of this document.

DOE relied on the engineering analysis and the shipments analysis to estimate the potential reallocation of fixed foundry overhead to the remaining cast-iron shipments under a condensing standard. For foundry owners, DOE estimated a potential reallocation of $20 per-unit to gas-fired steam, oil-fired hot water, and oil-fired steam shipments under a condensing standard. DOE also asked manufacturers during confidential interviews to estimate the potential reallocation costs but did not receive sufficient quantitative feedback to inform the analysis.

To derive the $20 reallocation cost, DOE first used the engineering analysis to estimate the average per-unit overhead and depreciation costs associated with gas-fired hot water cast-iron heat exchangers. To avoid underestimating the fixed foundry costs, DOE considered all the heat exchanger overhead and depreciation as fixed costs. DOE estimates that the average per-unit overhead and depreciation costs associated with gas-fired hot water cast-iron heat exchangers is approximately $24. DOE then used the reference year shipments distribution by product class from the shipments analysis, foundry market share assumptions, and the product database to calculate the cumulative foundry overhead and depreciation costs associated with gas-fired hot water cast-iron heat exchangers and reallocated those cumulative costs evenly across the remaining cast-iron product class shipments (*i.e.*, gas-fired steam, oil-fired hot water, and oil-fired steam). In the subgroup analysis GRIM, this $20 reallocation cost was added to the MPCs for gas-fired steam, oil-fired hot water, and oil-fired steam in the standards cases where gas-fired hot water boilers would need to meet a condensing level.

DOE requests comment on the $20 per-unit reallocation cost for gas-fired steam, oil-fired hot water, and oil-fired steam boilers under a condensing standard for gas-fired hot water boilers, as well as the methodology used to derive the estimate.

As discussed in section IV.J.2.d of this document, the industry GRIM included two manufacturer markup scenarios to represent uncertainty regarding the potential impacts on prices and profitability for manufacturers following the implementation of amended energy conservation standards: (1) a preservation of gross margin percentage scenario; and (2) a preservation of operating profit scenario. For the subgroup analysis GRIM, DOE customized these scenarios to account for the additional price and profitability impacts for foundry owners under a condensing standard.

To establish an upper-bound to industry profitability under potential amended standards, DOE maintained the same scenario, the preservation of gross margin percentage scenario, as modeled in the industry GRIM. The preservation of gross margin percentage applies a "gross margin percentage" of 29 percent for all product classes and all efficiency levels.[160] This scenario assumes that a foundry owner's per-unit dollar profit would increase as MPCs increase in the standards cases. Under a condensing

[160] The gross margin percentage of 29 percent is based on a manufacturer markup of 1.41.

standard, foundry owner's dollar profit for a cast-iron unit (*e.g.*, oil-fired hot water boiler) would increase relative to non-foundry owners due to the $20 increase in MPC.

DOE modeled the preservation of market MSP scenario to establish the conservative lower (or more severe) bound to foundry owner profitability. To develop this scenario, DOE used the manufacturer markups from the preservation of operating profit scenario developed in the industry GRIM as a starting point. As discussed in section IV.J.2.d of this document, the preservation of operating profit scenario reflects manufacturers' concerns about their inability to maintain margins as MPCs increase to reach more-stringent efficiency levels. For the subgroup analysis GRIM, as foundry owners' cost of production goes up for gas-fired steam, oil-fired hot water, and oil-fired steam product classes, foundry owners reduce their manufacturer markups to a level that maintains the industry average MSPs calibrated under the preservation of operating profit scenario. In essence, foundry owners cannot charge more than their competitors that do not have foundry assets, and consequently, they have reduced profit on each unit sold. DOE implemented this scenario in the subgroup analysis GRIM by lowering the manufacturer markups for gas-fired steam, oil-fired hot water, and oil-fired steam product classes at TSL 2 through TSL 4 to yield approximately the same MSP in the standards case as in the standards case in the industry GRIM. The implicit assumptions behind this are that foundry owners cannot raise their MSP to offset price increases that are a result of the loss of cast-iron gas-fired hot water sales and have reduced operating profit in absolute dollars after the amended standard takes effect.

These modeling assumptions are intended to reflect manufacturer comments a condensing standard for gas-fired hot water boilers would results in increases in cast-iron prices in other boiler types.

Table V.21 Manufacturer Impact Analysis Consumer Boiler Subgroup Results

	Unit	No-New-Standards Case	TSL 1	TSL 2	TSL 3	TSL 4
INPV	*2022$ millions*	101.2	097.6 to 098.2	089.5 to 094.3	086.2 to 091.7	074.9 to 098.2
Change in INPV*	*2022$ millions*	-	(3.6) to (3.0)	(9.0) to (4.2)	(12.3) to (6.9)	(23.7) to (0.3)
	%	-	(3.5) to (3.0)	(9.2) to (4.3)	(12.5) to (7.0)	(24.0) to (0.3)
Free Cash Flow (2029)*	*2022$ millions*	8.8	6.2	2.6	0.2	(5.4)
Change in Free Cash Flow (2029)*	*%*	-	(28.8)	(70.0)	(98.0)	(162.9)
Capital Conversion Costs	*2022$ millions*	-	2.5	11.0	14.9	19.7
Product Conversion Costs	*2022$ millions*	-	3.9	2.9	4.7	14.3
Total Conversion Costs	*2022$ millions*	-	6.5	13.9	19.6	34.0

*Note: Parentheses indicate negative (-) values.

The subgroup analysis results indicate that manufacturers that own domestic foundries would fare worse than competitors that do not own domestic foundries under amended standards that require condensing levels for gas-fired hot water boilers. This occurs because manufacturers that own domestic foundries must recover foundry investments over smaller number of sales, given that gas-fired hot water boilers currently account for 45 percent of cast-iron boilers covered under this rulemaking. That cost recovery takes the form of MPC increases for gas-fired steam, oil-fired hot water, and oil-fired steam boilers. Manufacturers that own foundries face reduced profitability, as DOE assumes they cannot pass the foundry-related MPC increases onto their customers. However, even with these additional cost increases, DOE's modeling suggests that manufacturers that own foundries would be able to continue to operate, albeit with reduced profitability and at reduced INPV relative to the overall industry.

DOE requests comment on the potential impacts on consumer boiler manufacturers that own domestic foundry assets including impacts but not limited to those vital to national security or critical infrastructure at the TSLs analyzed in this NOPR analysis.

e. Cumulative Regulatory Burden

One aspect of assessing manufacturer burden involves looking at the cumulative impact of multiple DOE standards and the product-specific regulatory actions of other Federal agencies 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.

DOE evaluates product-specific regulations that will take effect approximately three years before or after the estimated 2030 compliance date of any amended energy conservation standards for consumer boilers. This information is presented in Table V.22.

Table V.22 Compliance Dates and Expected Conversion Expenses of Federal Energy Conservation Standards Affecting Consumer Boiler Original Equipment Manufacturers

Federal Energy Conservation Standard	Number of OEMs*	Number of OEMs Affected by Today's Rule**	Approx. Standards Compliance Year	Industry Conversion Costs *(Millions $)*	Industry Conversion Costs / Product Revenue*** *(%)*
Commercial Water Heating Equipment† 87 FR 30610 (May 19, 2022)	14	11	2026	$34.60 (2020$)	4.7%
Consumer Furnaces† 87 FR 40590 (July 7, 2022)	15	4	2029	$150.6 (2020$)	1.4%
Consumer Clothes Dryers† 87 FR 51734 (August 23, 2022)	15	1	2027	$149.7 (2020$)	1.8%
Consumer Conventional Cooking Products 88 FR 6818† (February 1, 2023)	34	1	2027	$183.4 (2021$)	1.2%
Residential Clothes Washers† 88 FR 13520 (March 3, 2023)	19	1	2027	$690.8 (2021$)	5.2%
Refrigerators, Freezers, and Refrigerator-Freezers† 88 FR 12452 (February 27, 2023)	49	1	2027	$1,323.6 (2021$)	3.8%
Room Air Conditioners 88 FR 34298 (May 26, 2023)	8	1	2026	$24.8 (2021$)	0.4%
Microwave Ovens 88 FR 39912 (June 20, 2023)	18	1	2026	$46.1 (2021$)	0.7%
Miscellaneous Refrigeration Products† 88 FR 19382 (March 31, 2023)	38	1	2029	$126.9 (2021$)	3.1%
Dishwashers† 88 FR 32514 (May 19, 2023)	22	1	2027	$125.6 (2021$)	2.1%
Consumer Pool Heaters 88 FR 34624 (May 30, 2023)	20	3	2028	$48.4 (2021$)	1.5%

* This column presents the total number of OEMs identified in the energy conservation standard rule that is contributing to cumulative regulatory burden.
** This column presents the number of OEMs producing consumer boilers that are also listed as OEMs in the identified energy conservation standard that is contributing to cumulative regulatory burden.
*** This column presents industry conversion costs as a percentage of product revenue during the conversion period. Industry conversion costs are the upfront investments manufacturers must make to sell compliant products/equipment.

The revenue used for this calculation is the revenue from just the covered product/equipment associated with each row. The conversion period is the time frame over which conversion costs are made and lasts from the publication year of the final rule to the compliance year of the energy conservation standard. The conversion period typically ranges from 3 to 5 years, depending on the rulemaking.
† These rulemakings are at the NOPR stage, and all values are subject to change until finalized through publication of a final rule.

DOE requests information regarding the impact of cumulative regulatory burden on manufacturers of consumer boilers associated with multiple DOE standards or product-specific regulatory actions of other Federal agencies in addition to state or local regulations.

3. National Impact Analysis

This section presents DOE's estimates of the national energy savings and the NPV of consumer benefits that would result from each of the TSLs considered as potential amended standards.

a. Significance of Energy Savings

To estimate the energy savings attributable to potential amended standards for consumer boilers, DOE compared their energy consumption under the no-new-standards case to their anticipated energy consumption under each TSL. The savings are measured over the entire lifetime of products purchased in the 30-year period that begins in the year of anticipated compliance with amended standards (2030–2059). Table V.19 presents DOE's projections of the national energy savings for each TSL considered for consumer boilers. The savings were calculated using the approach described in section IV.H.2 of this document.

Table V.23 Cumulative National Energy Savings for Consumer Boilers; 30 Years of Shipments (2030–2059)

	Trial Standard Level			
	1	**2**	**3**	**4**
	quads			
Primary energy	0.05	0.31	0.61	0.73
FFC energy	0.06	0.36	0.68	0.83

OMB Circular A-4[161] 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.[162] The review timeframe established in EPCA is generally not synchronized with the product lifetime, product manufacturing cycles, or other factors specific to consumer boilers. 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

[161] U.S. Office of Management and Budget, *Circular A-4: Regulatory Analysis* (Sept. 17, 2003) (Available at: *www.whitehouse.gov/wp-content/uploads/legacy_drupal_files/omb/circulars/A4/a-4.pdf)* (Last accessed March 7, 2023).

[162] 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, 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.24. The impacts are counted over the lifetime of consumer boilers purchased in 2030–2038.

Table V.24 Cumulative National Energy Savings for Consumer Boilers; 9 Years of Shipments (2030–2038)

	Trial Standard Level			
	1	2	3	4
	quads			
Primary energy	0.02	0.13	0.24	0.27
FFC energy	0.03	0.15	0.27	0.30

b. Net Present Value of Consumer Costs and Benefits

DOE estimated the cumulative NPV of the total costs and savings for consumers that would result from the TSLs considered for consumer boilers. In accordance with OMB's guidelines on regulatory analysis,[163] DOE calculated NPV using both a 7-percent and a 3-percent real discount rate. Table V.21 shows the consumer NPV results with impacts counted over the lifetime of products purchased in 2030–2059.

Table V.25 Cumulative Net Present Value of Consumer Benefits for Consumer Boilers; 30 Years of Shipments (2030–2059)

Discount Rate	Trial Standard Level			
	1	2	3	4
	billion 2022$			
3 percent	0.16	0.73	2.27	(2.15)
7 percent	0.01	0.19	0.72	(1.55)

The NPV results based on the aforementioned 9-year analytical period are presented in Table V.22. The impacts are counted over the lifetime of products

[163] U.S. Office of Management and Budget, *Circular A-4: Regulatory Analysis* (Sept. 17, 2003) (Available at: *www.whitehouse.gov/wp-content/uploads/legacy_drupal_files/omb/circulars/A4/a-4.pdf)* (Last accessed March 7, 2023).

purchased in 2030–2038. As mentioned previously, such results are presented for informational purposes only and are not indicative of any change in DOE's analytical methodology or decision criteria.

Table V.26 Cumulative Net Present Value of Consumer Benefits for Consumer Boilers; 9 Years of Shipments (2030–2038)

Discount Rate	Trial Standard Level			
	1	2	3	4
	billion 2022$			
3 percent	0.11	0.47	1.22	(0.41)
7 percent	0.01	0.15	0.47	(0.72)

The previous results reflect the use of a default trend to estimate the change in price for consumer boilers over the analysis period (see section IV.F.1 of this document). DOE also conducted a sensitivity analysis that considered one scenario with a lower rate of price decline than the reference case and one scenario with a higher rate of price decline than the reference case. The results of these alternative cases are presented in appendix 10C of the NOPR TSD. In the high-price-decline case, the NPV of consumer benefits is higher than in the default case. In the low-price-decline case, the NPV of consumer benefits is lower than in the default case.

c. Indirect Impacts on Employment

It is estimated that that amended energy conservation standards for consumer boilers would reduce energy expenditures for consumers of those products, with the resulting net savings being redirected to other forms of economic activity. These expected shifts in spending and economic activity could affect the demand for labor. As described in section IV.N of this document, DOE used an input/output model of the U.S.

economy to estimate indirect employment impacts of the TSLs that DOE considered. There are uncertainties involved in projecting employment impacts, especially changes in the later years of the analysis. Therefore, DOE generated results for near-term timeframes (2030–2035), where these uncertainties are reduced.

The results suggest that the proposed standards would be 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 NOPR TSD presents detailed results regarding anticipated indirect employment impacts.

4. Impact on Utility or Performance of Products

As discussed in section III.G.1.d of this document, DOE has tentatively concluded that the standards proposed in this NOPR would not lessen the utility or performance of the consumer boilers under consideration in this proposed rulemaking. Manufacturers of these products currently offer units that meet or exceed the proposed 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.G.1.e of this document, the Attorney General determines the impact, if any, of any lessening of competition likely to result from a proposed standard, and transmits such determination in writing to the Secretary, together with an analysis of the nature and extent of such impact. To assist the Attorney General in making this determination, DOE has provided DOJ with copies of this NOPR and the accompanying TSD for review. DOE will consider DOJ's comments on the proposed rule in determining whether to proceed to a final rule. DOE will publish and respond to DOJ's comments in that document.

DOE invites comment from the public regarding the competitive impacts that are likely to result from this proposed rule. In addition, stakeholders may also provide comments separately to DOJ regarding these potential impacts. See the **ADDRESSES** section for information regarding how to send comments to DOJ.

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 NOPR 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 consume boilers is expected to yield environmental benefits in the form of reduced emissions of certain air pollutants and greenhouse gases. Table V.27 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 NOPR TSD.

Table V.27 Cumulative Emissions Reduction for Consumer Boilers Shipped in 2030–2059

	Trial Standard Level			
	1	**2**	**3**	**4**
Power Sector Emissions				
CO_2 (*million metric tons*)	3.7	18	34	41
CH_4 (*thousand tons*)	0.10	0.38	0.75	0.89
N_2O (*thousand tons*)	0.05	0.07	0.16	0.17
NO_X (*thousand tons*)	3.3	16	30	36
SO_2 (*thousand tons*)	1.1	1.0	2.6	2.6
Hg (*tons*)	(0.0002)	(0.001)	(0.001)	(0.001)
Upstream Emissions				
CO_2 (*million metric tons*)	0.6	3	5	6
CH_4 (*thousand tons*)	30	241	437	531
N_2O (*thousand tons*)	0.00	0.01	0.01	0.02
NO_X (*thousand tons*)	7.8	40	75	89
SO_2 (*thousand tons*)	0.1	0.1	0.2	0.2
Hg (*tons*)	0.00001	0.000003	0.00001	0.00001
Total FFC Emissions				
CO_2 (*million metric tons*)	4.3	21	39	47
CH_4 (*thousand tons*)	30	241	438	532
N_2O (*thousand tons*)	0.05	0.08	0.17	0.19
NO_X (*thousand tons*)	11	57	105	126
SO_2 (*thousand tons*)	1.2	1.1	2.7	2.8
Hg (*tons*)	(0.0002)	(0.001)	(0.001)	(0.001)

Note: Negative values in parentheses refer to an increase in emissions.

As part of the analysis for this proposed rulemaking, DOE estimated monetary benefits likely to result from the reduced emissions of CO_2 that DOE estimated for each of the considered TSLs for consumer boilers. Section IV.L of this document discusses the SC-CO_2 values that DOE used. Table V.28 presents the value of CO_2 emissions reduction at each TSL for each of the SC-CO_2 cases. The time-series of annual values is presented for the proposed TSL in chapter 14 of the NOPR TSD.

Table V.28 Present Value of CO_2 Emissions Reduction for Consumer Boilers Shipped in 2030–2059

TSL	SC-CO_2 Case			
	Discount Rate and Statistics			
	5%	3%	2.5%	3%
	Average	Average	Average	95th percentile
	million 2022$			
1	39	172	270	522
2	184	814	1,284	2,467
3	332	1,482	2,343	4,489
4	407	1,800	2,840	5,457

As discussed in section IV.L.1.b of this document, DOE estimated the climate benefits likely to result from the reduced emissions of methane and N_2O that DOE estimated for each of the considered TSLs for consumer boilers. Table V.29 presents the value of the CH_4 emissions reduction at each TSL, and Table V.30 presents the value of the N_2O emissions reduction at each TSL. The time-series of annual values is presented for the proposed TSL in chapter 14 of the NOPR TSD.

Table V.29 Present Value of Methane Emissions Reduction for Consumer Boilers Shipped in 2030-2059

TSL	SC-CH_4 Case			
	Discount Rate and Statistics			
	5%	3%	2.5%	3%
	Average	Average	Average	95th percentile
	million 2022$			
1	13	40	56	106
2	99	306	431	811
3	174	544	767	1,438
4	217	671	944	1,778

Table V.30 Present Value of Nitrous Oxide Emissions Reduction for Consumer Boilers Shipped in 2030-2059

TSL	SC-N_2O Case			
	Discount Rate and Statistics			
	5%	3%	2.5%	3%
	Average	Average	Average	95th percentile
	million 2022$			
1	0.2	0.7	1.1	1.8
2	0.3	1.1	1.7	2.9
3	0.6	2.3	3.7	6.2
4	0.6	2.6	4.0	6.9

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 that the proposed standards would be economically justified even without inclusion of monetized benefits of reduced GHG emissions.

DOE also estimated the monetary value of the health benefits associated with NO_X and SO_2 emissions reductions anticipated to result from the considered TSLs for consumer boilers. The dollar-per-ton values that DOE used are discussed in section IV.L of this document. Table V.31 presents the present value for NO_X emissions reduction for each TSL calculated using 7-percent and 3-percent discount rates, and Table V.32 presents similar results for SO_2 emissions reductions. The results in these tables reflect application of EPA's low dollar-per-ton values, which DOE used to be conservative. The time-series of annual values is presented for the proposed TSL in chapter 14 of the NOPR TSD.

Table V.31 Present Value of NO_X Emissions Reduction for Consumer Boilers Shipped in 2030-2059

TSL	7% Discount Rate	3% Discount Rate
	million 2022$	
1	132	359
2	625	1,791
3	1,102	3,251
4	1,389	3,967

Table V.32 Present Value of SO_2 Emissions Reduction for Consumer Boilers Shipped in 2030-2059

TSL	7% Discount Rate	3% Discount Rate
	million 2022$	
1	14	41
2	12	34
3	34	94
4	35	98

Not all the public health and environmental benefits from the reduction of greenhouse gases, NOx, and SO_2 are captured in the values above, and additional unquantified benefits from the reductions of those pollutants as well as from the reduction of direct PM and other co-pollutants may be significant. DOE has not included monetary benefits of the reduction of Hg emissions because the amount of reduction is very small.

7. Other Factors

The Secretary of Energy, in determining whether a standard is economically justified, may consider any other factors that the Secretary deems to be relevant. (42 U.S.C. 6295(o)(2)(B)(i)(VII)) No other factors were considered in this analysis.

8. Summary of Economic Impacts

Table V.33 presents the NPV values that result from adding the estimates of the potential economic benefits resulting from reduced GHG, 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 consumer boilers, and are measured for the lifetime of products shipped in 2030-2059. The climate benefits associated with reduced GHG emissions resulting from the adopted standards are global benefits, and are also calculated based on the lifetime of consumer boilers shipped in 2030-2059.

Table V.33 Consumer NPV Combined with Present Value of Climate Benefits and Health Benefits

Category	TSL 1	TSL 2	TSL 3	TSL 4
Using 3% Discount Rate for Consumer NPV and Health Benefits (billion 2022$)				
5% Average SC-GHG case	0.6	2.8	6.1	2.5
3% Average SC-GHG case	0.8	3.7	7.6	4.4
2.5% Average SC-GHG case	0.9	4.3	8.7	5.7
3% 95th percentile SC-GHG case	1.2	5.8	11.5	9.2
Using 7% Discount Rate for Consumer NPV and Health Benefits (billion 2022$)				
5% Average SC-GHG case	0.2	1.1	2.4	0.5
3% Average SC-GHG case	0.4	2.0	3.9	2.3
2.5% Average SC-GHG case	0.5	2.5	5.0	3.7
3% 95th percentile SC-GHG case	0.8	4.1	7.8	7.1

C. Conclusion

When considering new or amended energy conservation standards, the standards that DOE adopts for any type (or class) of covered product must be designed to achieve the maximum improvement in energy efficiency that the Secretary determines is technologically feasible and economically justified. (42 U.S.C. 6295(o)(2)(A)) In determining whether a standard is economically justified, the Secretary must determine whether the benefits of the standard exceed its burdens by, to the greatest extent practicable, considering the seven statutory factors discussed previously. (42 U.S.C. 6295(o)(2)(B)(i)) The new or amended standard must also result in significant conservation of energy. (42 U.S.C. 6295(o)(3)(B))

For this NOPR, DOE considered the impacts of amended standards for consumer boilers at each TSL, beginning with the maximum technologically feasible level, to determine whether that level was economically justified. Where the max-tech level was not justified, DOE then considered the next most efficient level and undertook the same evaluation until it reached the highest efficiency level that is both technologically feasible and economically justified and saves a significant amount of energy. DOE refers to this process as the "walk-down" analysis.

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 or informational asymmetries; (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, or between current and subsequent owners). Having less than perfect foresight and a high degree of uncertainty about the future, consumers may trade off these types of investments at a higher-than-expected rate between current consumption and uncertain future energy cost savings.

In DOE's current regulatory analysis, potential changes in the benefits and costs of a regulation due to changes in consumer purchase decisions are included in two ways. First, if consumers forego the purchase of a product in the standards case, this decreases sales for product manufacturers, and the impact on manufacturers attributed to lost revenue is included in the MIA. Second, DOE accounts for energy savings attributable only to products actually used by consumers in the standards case; if a standard decreases the number of products purchased by consumers, this decreases the potential energy savings from an energy conservation standard. DOE provides estimates of shipments and changes in the volume of product purchases in chapter 9 of the NOPR TSD. However, DOE's current analysis does not explicitly control for heterogeneity in consumer preferences, preferences across subcategories of products or specific features, or consumer price sensitivity variation according to household income.[164]

While DOE is not prepared at present to provide a fuller quantifiable framework for estimating the benefits and costs of changes in consumer purchase decisions due to an energy conservation standard, DOE is committed to developing a framework that can support empirical quantitative tools for improved assessment of the consumer welfare impacts of appliance standards. DOE has posted a paper that discusses the issue of consumer welfare impacts of appliance energy conservation standards, and potential enhancements to the methodology by which these impacts are defined and estimated in the regulatory process.[165] DOE welcomes comments on how to more fully assess the potential impact of energy conservation standards on consumer choice and how to quantify this impact in its regulatory analysis in future rulemakings.

1. Benefits and Burdens of TSLs Considered for Consumer Boiler Standards

Table V.34 and Table V.35 summarize the quantitative impacts estimated for each TSL for consumer boilers. The national impacts are measured over the lifetime of consumer boilers purchased in the 30-year period that begins in the anticipated year of compliance with amended standards (2030–2059). The energy savings, emissions reductions, and value of emissions reductions refer to full-fuel-cycle results. DOE is

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[164] P.C. Reiss and M.W. White. Household Electricity Demand, Revisited. *Review of Economic Studies*. 2005. 72(3): pp. 853–883. doi: *10.1111/0034-6527.00354*.
[165] Sanstad, A.H., *Notes on the Economics of Household Energy Consumption and Technology Choice* (2010) Lawrence Berkeley National Laboratory (Available at: *www1.eere.energy.gov/buildings/appliance_standards/pdfs/consumer_ee_theory.pdf*) (Last accessed Jan. 3, 2023).

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 social cost of greenhouse gases, 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.34 Summary of Analytical Results for Consumer Boilers TSLs: National Impacts

Category	TSL 1	TSL 2	TSL 3	TSL 4
Cumulative FFC National Energy Savings				
Quads	0.06	0.36	0.68	0.83
Cumulative FFC Emissions Reduction				
CO_2 (*million metric tons*)	4	21	39	47
CH_4 (*thousand tons*)	30	241	438	532
N_2O (*thousand tons*)	0.05	0.08	0.17	0.19
NO_X (*thousand tons*)	11	57	105	126
SO_2 (*thousand tons*)	1.2	1.1	2.7	2.8
Hg (*tons*)	(0.0002)	(0.0013)	(0.0010)	(0.0009)
Present Value of Monetized Benefits and Costs (*3% discount rate, billion 2022$*)				
Consumer Operating Cost Savings	0.5	1.3	3.1	3.7
Climate Benefits*	0.2	1.1	2.0	2.5
Health Benefits**	0.4	1.8	3.3	4.1
Total Monetized Benefits†	1.1	4.3	8.5	10.3
Consumer Incremental Product Costs‡	0.34	0.62	0.82	5.9
Consumer Net Benefits	0.16	0.73	2.3	(2.2)
Total Net Monetized Benefits	0.78	3.7	7.6	4.4
Present Value of Monetized Benefits and Costs (*7% discount rate, billion 2022$*)				
Consumer Operating Cost Savings	0.19	0.51	1.1	1.4
Climate Benefits*	0.21	1.1	2.0	2.5
Health Benefits**	0.15	0.64	1.1	1.4
Total Monetized Benefits†	0.55	2.3	4.3	5.3
Consumer Incremental Product Costs‡	0.18	0.32	0.43	2.9
Consumer Net Benefits	0.01	0.19	0.72	(1.6)
Total Net Monetized Benefits	0.37	2.0	3.9	2.3

Note: This table presents the present value (in 2022) of costs and benefits associated with consumer boilers shipped in 2030−2059. These results include benefits which accrue after 2059 from the products shipped in 2030−2059.

* Climate benefits are calculated using four different estimates of the SC-CO_2, SC-CH_4 and SC-N_2O. Together, these represent the global SC-GHG. For presentational purposes of this table, the climate benefits associated with the average SC-GHG at a 3 percent discount rate are shown ; however, DOE emphasizes the 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 (for NO_X and SO_2) $PM_{2.5}$ precursor health benefits and (for NO_X) ozone precursor health

benefits, but will continue to assess the ability to monetize other effects such as health benefits from reductions in direct $PM_{2.5}$ emissions. The health benefits are presented at real discount rates of 3 and 7 percent. See section IV.L of this document for more details.
† Total and net benefits include consumer, climate, and health benefits. For presentation purposes, total and net benefits for both the 3-percent and 7-percent cases are presented using the average SC-GHG with 3-percent discount rate, but the Department does not have a single central SC-GHG point estimate. DOE emphasizes the importance and value of considering the benefits calculated using all four sets of SC-GHG estimates.
‡ Costs include incremental equipment costs as well as installation costs.

Table V.35 Summary of Analytical Results for Consumer Boilers TSLs: Manufacturer and Consumer Impacts

Category	TSL 1*	TSL 2*	TSL 3*	TSL 4*
Manufacturer Impacts: INPV (million 2022$)				
GHW (No-new-standards case INPV = 409.4)	399.1 to 401.5	371.9 to 389.0	364.6 to 384.4	316.7 to 428.9
GST (No-new-standards case INPV = 41.7)	41.7	41.7	41.7	30.8 to 32.5
OHW (No-new-standards case INPV = 73.5)	65.9 to 66.6	65.9 to 66.6	60.0 to 61.4	60.0 to 61.4
OST (No-new-standards case INPV = 7.5)	7.5	7.5	3.4 to 3.6	3.4 to 3.6
Total INPV (No-new-standards case INPV = 532.0)	514.1 to 517.1	487.0 to 504.8	469.7 to 491.2	411.9 to 527.6
Manufacturer Impacts: INPV (% change)				
GHW	(2.5) to (1.9)	(9.2) to (5.0)	(11.0) to (6.1)	(22.7) to 4.8
GST	0.0	0.0	0.0	(26.2) to (22.2)
OHW	(10.3) to (9.4)	(10.3) to (9.4)	(18.4) to (16.4)	(18.4) to (16.4)
OST	0.0	0.0	(54.6) to (52.7)	(54.6) to (52.7)
Total INPV	(3.4) to (2.8)	(8.5) to (5.1)	(11.7) to (7.7)	(22.6) to (0.8)
Consumer Average LCC Savings (2022$)				
GHW	(193)	275	768	(526)
GST	NA	NA	NA	(53)
OHW	374	374	666	666
OST	NA	NA	310	310
Shipment-Weighted Average*	(50)	296	737	(380)
Consumer Simple PBP (years)				
GHW	29.2	3.4	2.7	9.9
GSTs	NA	NA	NA	20.4
OHW	3.3	3.3	3.3	3.3
OST	NA	NA	5.5	5.5
Shipment-Weighted Average*	22.9	2.9	2.4	9.7
Percent of Consumers that Experience a Net Cost				
GHW	11	13	11	78
GST	NA	NA	NA	56
OHW	4	4	4	4
OST	NA	NA	14	14
Shipment-Weighted Average*	9	10	9	66

Note: Parentheses indicate negative (-) values. The entry "n.a." means not applicable because there is no change in the standard at certain TSLs (*i.e.*, standard remains at the baseline).
* Weighted by shares of each product class in total projected shipments in 2030.

DOE first considered TSL 4, which represents the max-tech efficiency levels for all product classes. These levels include 96-percent AFUE for consumer gas-fired hot water boilers (representing condensing operation), 83-percent AFUE for consumer gas-fired steam boilers, 88-percent AFUE for consumer oil-fired hot water boilers, and 86-percent AFUE for consumer oil-fired steam boilers. Gas-fired hot water, gas-fired steam, oil-fired hot water, and oil-fired steam boilers account for approximately 78 percent, 8 percent, 13 percent, and 1 percent of current industry shipments, respectively. 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 0.83 quads of energy, an amount DOE considers significant, primarily driven by the savings associated with condensing operation for gas-fired hot water boilers, the largest product class of consumer boilers. Consumer gas-fired hot water boilers save an estimated 0.73 quads. Consumer gas-fired steam boilers save an estimated 0.02 quads. Consumer oil-fired hot water boilers save an estimate 0.08 quads of energy. Consumer oil-fired steam boilers save an estimate 0.003 quads of energy.

Under TSL 4, the NPV is negative, indicating that consumer costs exceed consumer benefits. The NPV would be -$1.55 billion using a discount rate of 7 percent, and -$2.15 billion using a discount rate of 3 percent. Much of the consumer costs are driven by consumer gas-fired boilers, which have the largest share of shipments and a significant increase in total installed costs at the max-tech efficiency level to accommodate 96-percent AFUE compared to other product classes. The NPV for consumer gas-fired hot water boilers would be -$1.76 billion using a 7-percent discount rate, and -$2.80 billion using a 3-percent discount rate. The NPV for consumer gas-fired steam boilers would be -$0.02 billion using a 7-percent discount rate, and -$0.02 billion using a 3-percent discount rate. For consumer oil-fired boilers, the NPV is positive, indicating that consumer benefits exceed consumer costs. The NPV for consumer oil-fired hot water boilers would be $0.22 billion at a 7-percent discount rate and $0.65 billion at a 3-percent discount rate. The NPV for consumer oil-fired boilers (hot water and steam) would be $0.01 billion at a 7-percent discount rate and $0.02 billion at a 3-percent discount rate.

The cumulative emissions reductions at TSL 4 are 47 million metric tons of CO_2, 532 thousand tons of CH_4, 0.19 thousand tons of N_2O, and 126 thousand tons of NO_X, 2.8 thousand tons of SO_2, and an increase of 0.001 tons of Hg due to slightly higher electricity consumption. 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 $2.5 billion. The estimated monetary value of the health benefits from reduced NO_X and SO_2 emissions at TSL 4 is $1.4 billion using a 7-percent discount rate and $4.1 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 $2.3 billion. Using a 3-percent discount rate for all benefits and costs, the estimated total NPV at TSL 4 is $4.4 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 cost of $526 for consumer gas-fired hot water boilers, a cost of $53 for consumer gas-fired steam boilers, a savings of $666 for consumer oil-fired hot water boilers, and a savings of $310 for consumer oil-fired steam boilers. The average consumer costs exceed the benefits for gas-fired boilers and the average consumer benefits exceed the costs for oil-fired boilers at TSL 4. For example, the average total installed costs for gas-fired hot water boilers are $1,292 higher at max-tech compared to the baseline efficiency level, with only a corresponding savings of $130 in first-year operating costs. In contrast, the average total installed costs for oil-fired hot water boilers are only $192 higher at max-tech compared to the baseline efficiency level, with a corresponding savings of $59 in first-year operating costs. The fraction of consumers experiencing a net LCC cost is 78 percent for consumer gas-fired hot water boilers, 56 percent for consumer gas-fired steam boilers, 4 percent for consumer oil-fired hot water boilers, and 14 percent for consumer oil-fired steam boilers. For a majority of gas-fired boiler consumers, the costs exceed the benefits.

At TSL 4, the projected change in INPV ranges from a decrease of $120.0 million to a decrease of $4.3 million, which corresponds to decreases of 22.6 percent and 4.3 percent, respectively. Industry conversion costs could reach $170.1 million as gas-fired hot water boiler manufacturers develop or expand their production capacity for condensing models and work with suppliers to develop new condensing heat exchangers that can meet the max-tech efficiency of 96-percent AFUE, and as manufacturers of other product classes invest in higher-efficiency non-condensing designs.

At TSL 4, all gas-fired hot water boilers must transition to the max-tech condensing technology. This is a significant technological shift and may be challenging for many manufacturers. Out of the 24 gas-fired hot water boiler OEMs, only six OEMs offer models that meet the efficiencies required by TSL 4. Less than 5 percent of gas-fired hot water model listings can meet the 96-percent AFUE required. The projected change in INPV for the gas-fired hot water industry ranges from a decrease of $92.8 million to an increase of $19.5 million, which correspond to -22.7 percent and 4.8 percent, respectively. The lower bound is driven by the industry conversion costs of $117.4 million.

With 95 percent of all model offerings now on the market rendered obsolete, all 24 manufacturers would need to re-evaluate and redesign their portfolio of product offerings. Many OEMs that have extensive condensing gas-fired hot water product offerings do not have any models that can meet max-tech. Even OEMs that offer some max-tech models today would need to allocate extensive technical resources to provide max-tech offerings across the full range of capacities to serve their customers. Manufacturers that are heavily invested in the non-condensing market would likely need to re-orient their role in the market and determine how to compete in a marketplace where there is only one efficiency level.

Traditionally, manufacturers have designed their product lines to support a range of models with varying input capacities, and the efficiency has varied between models within the line. In reviewing available models, DOE found that manufacturers generally only have one or two input capacities optimized to achieve 96-percent AFUE within product lines, while the remaining input capacities are at a lower AFUE. This suggests that manufacturers would have to individually redesign each model within product lines to ensure all models can achieve the max-tech level. Redesign by individual model would necessitate a significant increase in design effort for manufacturers. Additionally, for manufacturers who source condensing heat exchangers (which is the majority of OEMs producing condensing boilers), there is concern that the relatively lower shipment volumes of boilers in the U.S. market (relative to international markets for boilers) will make it difficult to find suppliers willing to produce heat exchanger designs that would allow all models within their gas-fired hot water product lines to meet 96-percent AFUE, as each heat exchanger design would need to be optimized for a given input capacity. The need for gas-fired hot water manufacturers to invest heavily in redesign drives the industry's product conversion costs to $39.5 million.

The push toward new product designs would also require changes to the manufacturing facilities. While most manufacturer offer some condensing models today, a max-tech standard would accelerate the market shift to condensing products, and all manufacturers would likely need to make capital investments to extend or add production lines for gas-fired hot water boilers. Industry capital conversion costs could reach $77.9 million.

Gas-fired steam shipments account for approximately 10 percent of current industry shipments. Oil-fired hot water shipments account for approximately 14 percent of current industry shipments. Oil-fired steam shipments account for approximately 1 percent of current industry shipments. The technology options to improve efficiency are similar across the three product classes. The max-tech efficiency level at TSL 4 for these three product classes does not require a shift to condensing designs and does not dramatically alter the manufacturing process.

All four gas-fired steam boiler OEMs offer at least one model that meets max-tech. However, only 8 percent of gas-fired steam model listings meet the efficiencies required by TSL 4. The projected change in INPV for the gas-fired steam industry ranges from a decrease of $10.9 million to a decrease of $9.3 million, which correspond to -22.6 percent and -22.2 percent, respectively. The potential losses in INPV are driven by the industry conversion costs of $19.9 million.

Out of the 11 oil-fired hot water boiler OEMs, two OEMs offer models that can meet max-tech. Approximately 3 percent of oil-fired hot water model listings are at max-tech. The projected change in INPV for the oil-fired hot water industry ranges from a decrease of $13.6 million to a decrease of $12.1 million, which correspond to -18.4 percent and -16.4 percent, respectively. The decrease in INPV is driven by the industry conversion costs of $25.6 million.

Of the four oil-fired steam boiler OEMs, two OEMs offer max-tech models. Approximately 22 percent of oil-fired steam model listings can meet TSL 4. The projected change in INPV for the oil-fired steam industry ranges from a decrease of $4.1 million to a decrease of $4.0 million, which correspond to -54.6 percent and -52.7

percent, respectively. The decrease in INPV is driven by the industry conversion costs of $7.2 million.

The design options available to increase the efficiency of gas-fired steam, oil-fired hot water, and oil-fired steam boilers are similar. Manufacturers may be able to meet max-tech efficiency for some models by adding additional heat exchanger sections. However, where additional sections are not sufficient, manufacturers may need to invest in the more time-intensive process of redesigning of the heat exchanger and in new castings and tooling to achieve max-tech efficiencies.

The Secretary tentatively concludes that at TSL 4 for consumer boilers, the benefits of energy savings, positive NPV of consumer benefits for the oil-fired boiler product classes, emission reductions, and the estimated monetary value of the emissions reductions would be outweighed by the economic burden on some consumers (particularly the majority of gas-fired boiler consumers) and the impacts on manufacturers of gas-fired hot water boilers, including the potentials for large conversion costs, for reduced product availability, and for substantial reductions in INPV. In particular, DOE notes that TSL 4 could lead to substantial upfront investments for the gas-fired hot water products, which account for the largest portion of shipments by product class. At max-tech, 95 percent of all model offerings would be made obsolete. All 24 manufacturers would need to re-evaluate and redesign their portfolio of product lines. Although the max-tech efficiency level has been demonstrated to be achievable for a wide range of input capacities, most product lines only have one or two models meeting the max-tech level, while the remaining input capacities are at a lower AFUE level. This suggests that even manufacturers who currently offer max-tech models would have to individually redesign each model within product lines to ensure all models can achieve the max-tech level. Additionally, manufactures would need to ramp up production capacity of max-tech condensing units, through expansion of existing production lines or addition of new lines. Furthermore, manufacturer raised concerns about their ability to source the custom heat exchangers necessary to optimize models at every input capacity to meet a standard set at 96-percent AFUE. The average LCC impact is negative for consumer gas-fired hot water and steam boilers, indicating that the consumer costs exceed the benefits. Consequently, the Secretary has tentatively 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 represents the max-tech efficiency levels for consumer oil-fired boilers, 95-percent AFUE for consumer gas-fired hot water boilers (representing condensing operation), and baseline efficiency levels (which would result in no amendment to the energy conservation standard) for consumer gas-fired steam boilers.

TSL 3 would save an estimated 0.69 quads of energy, an amount DOE considers significant, primarily driven by the savings associated with condensing operation for gas-fired hot water boilers, which are the largest product class of consumer boilers. Consumer gas-fired hot water boilers save an estimated 0.61 quads. Consumer oil-fired hot water boilers save an estimated 0.08 quads of energy. Consumer oil-fired steam boilers save an estimated 0.003 quads of energy. There are no savings from consumer gas-fired steam boilers at TSL 3, as DOE is not considering amendments to the energy conservation standard at this TSL.

Under TSL 3, the NPV is positive, indicating that consumer benefits exceed consumer costs across all product classes. The NPV would be \$0.72 billion using a discount rate of 7 percent, and \$2.27 billion using a discount rate of 3 percent. The NPV for consumer gas-fired hot water boilers would be \$0.49 billion using a 7-percent discount rate, and \$1.60 billion using a 3-percent discount rate. The NPV for consumer oil-fired hot water boilers would be \$0.22 billion at a 7-percent discount rate and \$0.65 billion at a 3-percent discount rate. The NPV for consumer oil-fired boilers (hot water and steam) would be \$0.01 billion at a 7-percent discount rate and \$0.02 billion at a 3-percent discount rate.

The cumulative emissions reductions at TSL 3 are 39 million metric tons of CO_2, 438 thousand tons of CH_4, 0.17 thousand tons of N_2O, 105 thousand tons of NO_X, and 2.7 thousand tons of SO_2, and an increase of 0.001 tons of Hg due to slightly higher electricity consumption. The estimated monetary value of the climate benefits from reduced GHG emissions (associated with the average SC-GHG at a 3-percent discount rate) at TSL 3 is \$2.0 billion. The estimated monetary value of the health benefits from reduced NO_X and SO_2 emissions at TSL 3 is \$1.1 billion using a 7-percent discount rate and \$3.3 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 \$3.9 billion. Using a 3-percent discount rate for all benefits and costs, the estimated total NPV at TSL 3 is \$7.6 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 $768 for consumer gas-fired hot water boilers, a savings of $666 for consumer oil-fired hot water boilers, and a savings of $310 for consumer oil-fired steam boilers. The average consumer benefits exceed the costs for these impacted product classes at TSL 3. There is no LCC impact for consumer gas-fired steam boilers at TSL 3, as the energy conservation standard is not being amended. The fraction of consumers experiencing a net LCC cost is 11 percent for consumer gas-fired hot water boilers, 4 percent for consumer oil-fired hot water boilers, and 14 percent for consumer oil-fired steam boilers. For a majority of boiler consumers of these impacted product classes, the benefits exceed the costs. There are no consumers with a net LCC cost for consumer gas-fired steam boilers at TSL 3, as the energy conservation standard is not being amended. Low-income consumers are not disproportionately impacted, as many are renters that either do not pay for equipment costs or energy costs. As such, the proportion of low-income consumers that are not impacted or who experience a net benefit are higher than in the main LCC analysis. Specifically, the fraction of low-income consumers experiencing a net LCC cost is 6 percent for consumer gas-fired hot water boilers, 1 percent for consumer oil-fired hot water boilers, and 4 percent for consumer oil-fired steam boilers. For a majority of low-income boiler consumers of these impacted product classes, the benefits exceed the costs. There are no low-income consumers with a net LCC cost for consumer gas-fired steam boilers at TSL 3, as the energy conservation standard is not being amended.

At TSL 3, the projected change in INPV ranges from a decrease of $62.2 million to a decrease of $40.7 million, which correspond to decreases of 11.7 percent and 7.7 percent, respectively. Industry conversion costs could reach $98.0 million. Gas-fired hot water boiler manufacturers develop or expand their production capacity for condensing models; however, DOE expects significantly lower product conversion costs than would be required at TSL 4. Manufacturers of oil-fired hot water and oil-fired steam boilers would need to invest in higher-efficiency non-condensing designs.

Out of the 24 gas-fired hot water OEMs, 18 OEMs offer products that meet the 95-percent AFUE required. Approximately 40 percent of gas-fired hot water model listings can meet TSL 3. The projected change in INPV for the gas-fired hot water industry ranges from a decrease of $44.9 million to a decrease of $25.0 million, which correspond to -11.0 percent and -6.1 percent, respectively. The lower bound is driven by the industry conversion costs of $65.2 million. The design options analyzed at TSL 3 for gas-fired hot water boilers included implementing a condensing stainless-steel heat exchanger with a premix modulating burner. As with TSL 4, manufacturers heavily invested in non-condensing gas-fired hot water boilers would need to develop or expand their condensing production capacity, which would necessitate new production lines and updates to the factory floor. However, unlike TSL 4, most manufacturers currently offer products that meet the 95-percent AFUE required. Additionally, TSL 3 reduces the need to redesign by optimizing design at the individual model level to meet amended standards. At TSL 3, industry product conversion costs decrease to $3.1 million.

At TSL 3, the efficiency level for gas-fired steam boilers is the baseline efficiency (82-percent AFUE). Therefore, all gas-fired steam shipments can meet TSL 3. When evaluating this product class in isolation, DOE expects minimal change in INPV for the gas-fired steam industry and zero conversion costs.

At TSL 3, the efficiency level for oil-fired hot water and oil-fired steam boilers is identical to TSL 4. The projected change in INPV for the oil-fired hot water industry ranges from a decrease of $13.6 million to a decrease of $12.1 million, which correspond to -18.4 percent and -16.4 percent, respectively. The decrease in INPV is driven by the industry conversion costs of $25.6 million. At TSL 3, the efficiency level for oil-fired steam boilers identical to TSL 4. The projected change in INPV for the oil-fired steam industry ranges from a decrease of $4.1 million to a decrease of $4.0 million, which correspond to -54.6 percent and -52.7 percent, respectively. The decrease in INPV is driven by the industry conversion costs of $7.2 million.

Oil-fired hot water and oil-fired steam manufacturers would need to redesign a large portion of their products. However, the redesign would rely on existing technologies. DOE expect manufactures to meet max-tech efficiency for some models by adding additional heat exchanger sections and vent dampers. However, where additional sections are not sufficient, manufacturers may need to invest in the more time-intensive process of redesigning the heat exchanger and in new castings and tooling to achieve max-tech efficiencies.

After considering the analysis and weighing the benefits and burdens, the Secretary tentatively concludes that a standard set at TSL 3 for consumer boilers would be economically justified. At this TSL, the average LCC savings for consumer gas-fired hot water boilers, consumer oil-fired hot water boilers, and consumer oil-fired steam boilers are positive. The FFC national energy savings are significant. The NPV of consumer benefits is positive for each impacted product classes using both a 3-percent and 7-percent discount rate. Notably, the benefits to consumers substantially outweigh the cost to manufacturers. At TSL 3, with regard to gas-fired hot water boilers, which account for approximately 75 percent of current industry shipments, most manufacturers offer a range of models that meet the efficiency level required. Out of the 24 gas-fired hot water OEMs, 18 OEMs offer around 252 models (accounting for 40 percent of gas-fired hot water model listings) that meet the 95-percent AFUE required. At TSL 3, the NPV of consumer benefits, even measured at the more conservative discount rate of 7 percent, is more than 900 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 $2.0 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 $1.1 billion (using a 7-percent discount rate) in health benefits—the rationale becomes stronger still.

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 that at TSL 3, the efficiency levels result in the largest LCC savings for each product class and the largest NPV for each product class compared to any other efficiency level. Additionally, the conversion costs for gas-fired hot water and gas-fired steam boiler at substantially lower at TSL 3.

Although DOE considered proposed amended standard levels for consumer boilers by grouping the efficiency levels for each product class into TSLs, DOE evaluates all analyzed efficiency levels for all product classes in its analysis.

For consumer gas-fired hot water boilers, TSL 3 includes an efficiency level (*i.e.*, EL 3) that is one level below the max-tech efficiency level. As discussed previously, at the max-tech efficiency level for gas-fired hot water boilers, there is an average LCC cost of $526 and a majority of consumers (78 percent) with a net LCC cost. Furthermore, for low-income consumers of gas-fired hot water boilers, there is an average LCC cost of $161 and 34 percent with a net LCC cost at the max-tech efficiency level. Additionally, conversion costs could reach $117.4 million for industry. At EL 4 (*i.e.*, the max-tech efficiency level for gas-fired hot water boilers), less than 5 percent of industry models would meet the amended standard. However, at EL 3 (*i.e.*, the efficiency level below max-tech), approximately 40 percent of industry models would meet the standard. Furthermore, redesign efforts for gas-fired hot water boilers would be significantly less at EL 3, as manufacturer would not need to optimize performance for every product line and input capacity individually to achieve the proposed efficiency level. This difference in redesign effort is the primary driver that reduces conversion costs down from $117.4 million at max-tech to $65.2 million at EL 3. The benefits of the max-tech efficiency level for consumer gas-fired hot water boilers do not outweigh the negative impacts to consumers and manufacturers. Therefore, DOE tentatively concludes that the max-tech efficiency level is not justified for consumer gas-fired hot water boilers. In contrast, EL 3 for consumer gas-fired hot water boilers results in positive average LCC savings of $768 and a minority of consumers (11 percent) with a net LCC cost. Similarly, for low-income consumers, the efficiency level below max-tech for consumer gas-fired hot water boilers results in positive average LCC savings of $643 and 9 percent with a net LCC cost. Additionally, greater than 50 percent of the shipments for consumer gas-fired hot water boilers is at or above EL 3, clearly supporting the viability of products at this efficiency level in the market. At this level, industry conversion costs are significantly lower at 65.2 million. Therefore, DOE tentatively concludes that EL 3 is justified for consumer gas-fired hot water boilers.

For consumer gas-fired steam boilers, TSL 3 includes the baseline efficiency level. The only efficiency level above baseline that was analyzed for consumer gas-fired steam boilers is the max-tech efficiency level, which results in an average LCC cost and a majority of consumers with a net LCC costs. The benefits of the max-tech efficiency level for consumer gas-fired steam boilers do not outweigh the negative impacts to consumers and manufacturers. Therefore, DOE tentatively concludes that the max-tech efficiency level is not justified and is not proposing to amend the energy conservation standard for consumer gas-fired steam boilers.

For consumer oil-fired hot water boilers, TSL 3 includes the max-tech efficiency level, which is the maximum level determined to be technologically feasible. The max-tech efficiency level for consumer oil-fired hot water boilers results in an average LCC savings of $666 and a minority of consumers (4 percent) with a net LCC cost. Similarly, for low-income consumers, the efficiency level below max-tech for consumer oil-fired hot water boilers results in positive average LCC savings of $603 and 1 percent with a net

LCC cost. The benefits of max-tech efficiency levels for consumer oil-fired hot water boilers outweigh the negative impacts to consumers and manufacturers. Therefore, DOE tentatively concludes that the max-tech efficiency level is justified for consumer oil-fired hot water boilers.

For consumer oil-fired steam boilers, TSL 3 includes the max-tech efficiency level, which is the maximum level determined to be technologically feasible. The max-tech efficiency level for consumer oil-fired steam boilers results in an average LCC savings of $310 and a minority of consumers (14 percent) with a net LCC cost. Similarly, for low-income consumers, the efficiency level below max-tech for consumer oil-fired steam boilers results in positive average LCC savings of $279 and 5 percent with a net LCC cost. The benefits of max-tech efficiency levels for consumer oil-fired hot water and steam boilers outweigh the negative impacts to consumers and manufacturers. Therefore, DOE tentatively concludes that the max-tech efficiency level is justified for consumer oil-fired hot water and steam boilers.

Therefore, based on the previous considerations, DOE proposes amended energy conservation standards for consumer boilers at TSL 3. The amended energy conservation standards for consumer boilers, which are expressed as an annual fuel utilization efficiency, are shown in Table V.32 of this document.

Table V.36 Proposed Amended Energy Conservation Standards for Consumer Boilers

Product Class	AFUE
Gas-fired Hot Water	95%
Gas-fired Steam	82%
Oil-fired Hot Water	88%

Oil-fired Steam	86%

2. Annualized Benefits and Costs of the Proposed 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$) of the benefits from operating products that meet the proposed standards (consisting primarily of operating cost savings from using less energy, minus increases in product purchase costs), and (2) the annualized monetary value of the climate and health benefits from emission reductions. Table V.37 shows the annualized values for consumer boilers under TSL 3, expressed in 2022$. 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 NO_X and SO_2 emissions, and the 3-percent discount rate case for climate benefits from reduced GHG emissions, the estimated cost of the standards proposed in this rule is $52 million per year in increased equipment costs, while the estimated annual benefits are $139 million in reduced equipment operating costs, $124 million in climate benefits, and $137 million in health benefits. In this case, the net benefit would amount to $348 million per year.

Using a 3-percent discount rate for all benefits and costs, the estimated cost of the proposed standards is $50 million per year in increased equipment costs, while the estimated annual benefits are $188 million in reduced operating costs, $124 million in climate benefits, and $204 million in health benefits. In this case, the net benefit would amount to $466 million per year.

Table V.37 Annualized Monetized Benefits and Costs of Proposed Energy Conservation Standards for Consumer Boilers (TSL 3)

	Million 2022$/year		
	Primary Estimate	**Low-Net-Benefits Estimate**	**High-Net-Benefits Estimate**
3% discount rate			
Consumer Operating Cost Savings	188	175	233
Climate Benefits*	124	121	144
Health Benefits**	204	200	237
Total Monetized Benefits†	516	496	613
Consumer Incremental Product Costs‡	50	58	38
Net Monetized Benefits	466	438	575
Change in Producer Cashflow‡‡	(6) - (4)	(6) - (4)	(6) - (4)
7% discount rate			
Consumer Operating Cost Savings	139	129	169
Climate Benefits* (3% discount rate)	124	121	144
Health Benefits**	137	135	158
Total Monetized Benefits†	400	385	470
Consumer Incremental Product Costs‡	52	59	41
Net Monetized Benefits	348	326	430
Change in Producer Cashflow‡‡	(6) - (4)	(6) - (4)	(6) - (4)

Note: This table presents the present value (in 2022) of the costs and benefits associated with consumer boilers shipped in 2030–2059. These results include benefits which accrue after 2059 from the products shipped in 2030–2059. The Primary, Low-Net-Benefits, and High-Net-Benefits Estimates utilize projections of energy prices from the *AEO 2022* Reference case, Low-Economic-Growth case, and High-Economic-Growth case, respectively. In addition, incremental equipment costs reflect a medium decline rate in the Primary Estimate, a low decline rate in the Low-Net-Benefits Estimate, and a high decline rate in the High-Net-Benefits Estimate. The methods used to derive projected price trends are explained in sections IV.F.1 and IV.H.3 of this document. Note that the Benefits and Costs may not sum to the Net Benefits due to rounding.

* Climate benefits are calculated using four different estimates of the global SC-GHG (see section IV.L of this document). 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 (for SO_2 and NO_X) $PM_{2.5}$ precursor health benefits and (for NO_X) ozone precursor health benefits, but will continue to assess the ability to monetize other effects such as health benefits from

reductions in direct $PM_{2.5}$ emissions. 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, but the Department does not have a single central SC-GHG point estimate.
‡ 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 product 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 9.7% that is estimated in the MIA (see chapter 12 of the NOPR TSD for a complete description of the industry weighted average cost of capital). For consumer boilers, those values are -$6 million and -$4 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 proposal 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 proposed rule, the annualized net benefits would range from $460 million to $462 million at 3-percent discount rate and would range from $342 million to $344 million at 7-percent discount rate. DOE seeks comment on this approach.

D. Reporting, Certification, and Sampling Plan

Manufacturers, including importers, must use product-specific certification templates to certify compliance to DOE. For consumer boilers, the certification template reflects the general certification requirements specified at 10 CFR 429.12 and the product-specific requirements specified at 10 CFR 429.18. As discussed in the previous paragraphs, DOE is not proposing to amend the product-specific certification requirements for these products.

VI. Procedural Issues and Regulatory Review

A. Review Under Executive Orders 12866 and 13563

Executive Order (E.O.)12866, "Regulatory Planning and Review," 58 FR 51735 (Oct. 4, 1993), as supplemented and reaffirmed by E.O. 13563, "Improving Regulation and Regulatory Review," 76 FR 3821 (Jan. 21, 2011), 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 proposed 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 proposed regulatory action constitutes a "significant regulatory action" under 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 proposed regulatory action, together with, to the extent feasible, a quantification of those costs; and an assessment, including the underlying analysis, of costs and benefits of potentially effective and reasonably feasible alternatives to the planned regulation, and an explanation why the planned regulatory action is preferable to the identified potential alternatives. These assessments are summarized in this preamble and further detail can be found in the technical support document for this proposed 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 (August 16, 2002), DOE published procedures and policies on February 19, 2003, to ensure that the potential impacts of its rules on small entities are properly considered during the rulemaking process. 68 FR 7990. DOE has made its procedures and policies available on the Office of the General Counsel's website (*www.energy.gov/gc/office-general-counsel*). DOE reviewed this proposed rule under the provisions of the Regulatory Flexibility Act and the policies and procedures published on February 19. 2003.

DOE has prepared the following IRFA for the products that are the subject of this proposed energy conservation standard rulemaking.

For manufacturers of consumer boilers, 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 size standards are listed by North American Industry Classification System (NAICS) code and industry description and are available at *www.sba.gov/document/support--table-size-standards*. Manufacturing of consumer boilers is classified under NAICS 333414, "Heating Equipment (except Warm Air Furnaces) Manufacturing." The SBA sets a threshold of 500 employees or fewer for an entity to be considered as a small business for this category. For the products under review, the SBA bases its small business definition on the total number of employees for a business, including the total number of employees of its parent company and any subsidiaries. An aggregated business entity with fewer employees than the listed limit is considered a small business.

1. Description of Reasons Why Action Is Being Considered

DOE is proposing amended energy conservation standards for consumer boilers. In a final rule published in the *Federal Register* on January 15, 2016 (January 2016 Final

Rule), DOE prescribed the current energy conservation standards for consumer boilers manufactured on and after January 15, 2021. 81 FR 2320, 2416–2417. EPCA provides that, not later than six years after the issuance of any final rule establishing or amending a standard, DOE must publish either a notice of determination that standards for the product do not need to be amended, or a NOPR including new proposed energy conservation standards (proceeding to a final rule, as appropriate). (42 U.S.C. 6295(m)(1))

2. Objectives of, and Legal Basis for, Rule

EPCA authorizes DOE to regulate the energy efficiency of a number of consumer products and certain industrial equipment. Title III, Part B of EPCA established the Energy Conservation Program for Consumer Products Other Than Automobiles. These products include consumer boilers, the subject of this document. (42 U.S.C. 6292(a)(5)) EPCA prescribed energy conservation standards for these products (42 U.S.C. 6295(f)(3)), and directs DOE to conduct future rulemakings to determine whether to amend these standards. (42 U.S.C. 6295(f)(4)(C)) EPCA further provides that, not later than six years after the issuance of any final rule establishing or amending a standard, DOE must publish either a notice of determination that standards for the product do not need to be amended, or a NOPR including new proposed energy conservation standards (proceeding to a final rule, as appropriate). (42 U.S.C. 6295(m)(1))

3. Description on Estimated Number of Small Entities Regulated

DOE conducted a market survey to identify potential small manufacturers of consumer boilers. DOE began its assessment by reviewing its Compliance Certification

Database (CCD),[166] supplemented by information in California Energy Commission's Modernized Appliance Efficiency Database System (MAEDbS),[167] AHRI's Directory of Certified Product Performance,[168] U.S. Environmental Protection Agency's ENERGY STAR product finder dataset,[169] individual company websites, and prior consumer boiler rulemakings to identify manufacturers of the covered product. DOE then consulted publicly-available data, such as manufacturer websites, manufacturer specifications and product literature, import/export logs (*e.g.,* bills of lading from Panjiva[170]), and basic model numbers, to identify original equipment manufacturers (OEMs) of covered consumer boilers. DOE further relied on public data and subscription-based market research tools (*e.g.,* Dun & Bradstreet reports[171]) to determine company, location, headcount, and annual revenue. DOE also asked industry representatives if they were aware of any small manufacturers during manufacturer interviews. DOE screened out companies that do not offer products covered by this rulemaking, do not meet the SBA's definition of a "small business," or are foreign-owned and operated.

DOE initially identified 24 OEMs that sell consumer boilers in the United States. Of the 24 OEMs identified, DOE tentatively determined that three companies qualify as small businesses and are not foreign-owned and operated.

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[166] U.S. Department of Energy's Compliance Certification Database is available at: *www.regulations.doe.gov/certification-data/#q=Product_Group_s%3A** (Last accessed Jan. 3, 2023).
[167] California Energy Commission's Modernized Appliance Efficiency Database System is available at: *cacertappliances.energy.ca.gov/Pages/ApplianceSearch.aspx* (Last accessed Jan. 3, 2023).
[168] AHRI's Directory of Certified Product Performance is available at: *www.ahridirectory.org/Search/SearchHome* (Last accessed Jan. 3, 2023).
[169] U.S. Environmental Protection Agency's ENERGY STAR product finder dataset is available at: *www.energystar.gov/products/products_list* (Last accessed Dec. 27, 2022).
[170] S&P Global. Panjiva Market Intelligence is available at: *panjiva.com/import-export/United-States* (Last accessed Feb. 28, 2023).
[171] D&B Hoovers subscription login is accessible at: *app.dnbhoovers.com/* (Last accessed August 24, 2022).

4. Description and Estimate of Compliance Requirements Including Differences in Cost, if Any, for Different Groups of Small Entities

AHRI stated that small OEMs will be impacted by this rulemaking, especially with respect to cast-iron boilers. (AHRI, No. 40 at p. 6)

Of the three small domestic OEMs identified, DOE tentatively determined that all three OEMs manufacture both gas-fired hot water and oil-fired hot water boilers. DOE identified these manufacturers through a review of EPA's ENERGY STAR dataset, prior DOE consumer boiler rulemakings, and DOE's CCD.

The first small OEM ("Manufacturer A" in Table VI.1 and Table VI.2) offers seven gas-fired hot water basic models and five oil-fired hot water basic models. DOE identified these models through the company website and available product literature. Of the seven gas-fired hot water basic models, five meet the efficiency required by TSL 3. Of the five oil-fired hot water basic models, four meet the efficiency required by TSL 3. Given the company's small market share in the U.S. consumer boiler market and existing range of high-efficiency boilers, this manufacturer may choose to discontinue the non-compliant models. Alternatively, the manufacturer may choose to redesign models in order to maintain a diversified portfolio with cost-competitive baseline models. To avoid underestimating the conversion costs this manufacturer could incur as a result of amended standards, DOE assumed this small business would choose to redesign or replace the non-compliant models. DOE used basic model counts (*i.e.*, the manufacturer's proportion of industry basic models) to scale the industry conversion costs, described in section IV.J.2.c of the proposed rule's notice of proposed rulemaking. 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. Product conversion costs would be driven by the development and testing necessary to develop compliant products. 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. For gas-fired hot water boilers, the design options analyzed at TSL 3 included implementing a condensing stainless-steel heat exchanger with a premix modulating burner. This small manufacturer may need to expand their condensing production capacity, which could necessitate updates to production lines and the factory floor. For oil-fired hot water boilers, DOE expects that some manufacturers would need to invest in new casting designs and tooling to meet TSL 3 efficiencies. Based on this manufacturer's model share, DOE estimates product conversion costs of $80,000 and capital conversion costs of $370,000. For this small manufacturer, total conversion costs are approximately 1.0 percent of company revenue over the 5-year conversion period.[172]

The second small OEM ("Manufacturer B" in Table VI.1 and Table VI.2) offers one gas-fired hot water model and six oil-fired hot water models based on their website information. According to the company's website, they do not offer any condensing gas-fired hot water boilers or max-tech (88 percent AFUE) oil-fired hot water boilers. Similarly, the third small OEM ("Manufacturer C" in Table VI.1 and Table VI.2) offers three gas-fired hot water models and 18 oil-fired hot water models, does not have any condensing gas-fired hot water boilers or max-tech oil-fired hot water boilers. Thus,

[172] According to D&B Hoovers, this small business has an estimated annual revenue of $8.8 million. DOE calculated total conversion costs as a percent of revenue over the 5-year conversion period using the following calculation: ($370,000+$80,000)/(5 years x $8,800,000).

neither small business offers any models that meet the efficiencies required by TSL 3. To offer condensing gas-fired hot water boilers, these small OEMs would have to decide whether to develop their own condensing heat exchanger production, source heat exchangers from Europe or Asia and assemble higher-efficiency products, or leave the market entirely. DOE believes both small OEMs currently source their non-condensing heat exchangers from third-party foundries. Given the high upfront cost of in-house development of condensing heat exchangers, DOE expects these small businesses will continue to source their heat exchangers. These manufacturers would need to develop their condensing production capacity, which would necessitate updated production lines. DOE used basic model counts to scale the industry conversion costs. DOE estimates that the second small OEM, with seven consumer boiler models, would incur product conversion costs of $402,000 and capital conversion costs of $360,000. For this small manufacturer, total conversion costs are approximately 3.4 percent of company revenue over the 5-year conversion period.[173] DOE estimates that the third small OEM, with 21 consumer boiler models, would incur product conversion costs of $1.2 million and capital conversion costs of $1.1 million. For this small manufacturer, total conversion costs are approximately 13.8 percent of company revenue over the 5-year conversion period.[174]

Table VI.1 Potential Small Business Impacts (TSL 3)

Company	# of Unique Basic Models	Conversion Costs ($ millions)	Annual Revenue ($ millions)	Conversion Period Revenue ($ millions)	Conversion Costs as a % of Conversion

[173] According to D&B Hoovers, this small business has an estimated annual revenue of $4.5 million. DOE calculated total conversion costs as a percent of revenue over the 5-year conversion period using the following calculation: ($402,000+$360,000)/(5 years x $4,500,000).

[174] According to D&B Hoovers, this small business has an estimated annual revenue of $3.3 million. DOE calculated total conversion costs as a percent of revenue over the 5-year conversion period using the following calculation: ($1,200,000 + $1,100,000)/(5 years x $3,300,000).

					Period Revenue
Manufacturer A	12	0.45	8.8	44.0	1.0%
Manufacturer B	7	0.76	4.5	22.5	3.4%
Manufacturer C	21	2.29	3.3	16.5	13.8%

Table VI.2 Estimated Small Business Conversion Costs by Product Class (TSL 3)

Company	Product Class	# of Unique Basic Models	Product Conversion Costs ($ millions)	Capital Conversion Costs ($ millions)
Manufacturer A	Gas-fired Hot Water	7	0.02	0.34
	Oil-fired Hot Water	5	0.07	0.03
Manufacturer B	Gas-fired Hot Water	1	0.01	0.17
	Oil-fired Hot Water	6	0.39	0.19
Manufacturer C	Gas-fired Hot Water	3	0.02	0.50
	Oil-fired Hot Water	18	1.18	0.58

DOE seeks comments, information, and data on the number of small businesses in the industry, the names of those small businesses, and their market shares by product class. DOE also requests comment on the potential impacts of the proposed standards on small manufacturers.

5. Duplication, Overlap, and Conflict with Other Rules and Regulations

DOE is not aware of any rules or regulations that duplicate, overlap, or conflict with the proposed rule.

6. Significant Alternatives to the Rule

The discussion in the previous section analyzes impacts on small businesses that would result from DOE's proposed rule, represented by TSL 3. In reviewing alternatives to the proposed rule, DOE examined energy conservation standards set at lower efficiency levels. While TSL 1 and TSL 2 would reduce impacts on small business manufacturers, it would come at the expense of a reduction in energy savings. TSL 1 achieves 91 percent lower energy savings compared to the energy savings at TSL 3. TSL 2 achieves 48 percent lower energy savings compared to energy savings at TSL 3.

Based on the presented discussion, establishing standards at TSL 3 balances the benefits of the energy savings at TSL 3 with the potential burdens place on consumer boiler manufacturers, including small business manufacturers. Accordingly, DOE does not propose one of the other TSLs considered in this analysis, or the other policy alternatives examined as part of the regulatory impact analysis and included in chapter 17 of the NOPR TSD.

Additional compliance flexibilities may be available through other means. EPCA provides that a manufacturer whose annual gross revenue from all of its operations does not exceed $8 million may apply for an exemption from all or part of an energy conservation standard for a period not longer than 24 months after the effective date of a final rule establishing the standard. (42 U.S.C. 6295(t)) Additionally, manufacturers subject to DOE's energy efficiency standards may apply to DOE's Office of Hearings and Appeals for exception relief under certain circumstances. Manufacturers should refer to 10 CFR part 430, subpart E, and 10 CFR part 1003 for additional details.

C. Review Under the Paperwork Reduction Act of 1995

Manufacturers of consumer boilers must certify to DOE that their products comply with any applicable energy conservation standards. In certifying compliance, manufacturers must test their products according to the DOE test procedures for consumer boilers, including any amendments adopted for those test procedures. DOE has established regulations for the certification and recordkeeping requirements for all covered consumer products and commercial equipment, including consumer boilers. (*See generally* 10 CFR part 429). The collection-of-information requirement for the certification and recordkeeping is subject to review and approval by OMB under the Paperwork Reduction Act (PRA). This requirement has been approved by OMB under OMB control number 1910-1400. Public reporting burden for the certification is estimated to average 35 hours per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information.

DOE is not proposing to amend the certification or reporting requirements for consumer boilers in this proposed rulemaking. Instead, DOE may consider proposals to amend the certification requirements and reporting for consumer boilers under a separate rulemaking regarding appliance and equipment certification. DOE will address changes to OMB Control Number 1910-1400 at that time as necessary.

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

DOE is analyzing this proposed regulation in accordance with the National Environmental Policy Act of 1969 (NEPA) and DOE's NEPA implementing regulations (10 CFR part 1021). DOE's regulations include a categorical exclusion for rulemakings that establish energy conservation standards for consumer products or industrial equipment. 10 CFR part 1021, subpart D, appendix B5.1. DOE anticipates that this rulemaking qualifies for categorical exclusion B5.1 because it is a rulemaking that establishes energy conservation standards for consumer products or industrial equipment, none of the exceptions identified in categorical exclusion B5.1(b) apply, no extraordinary circumstances exist that require further environmental analysis, and it otherwise meets the requirements for application of a categorical exclusion. *See* 10 CFR 1021.410. Therefore, DOE has initially determined that promulgation of this proposed 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. DOE will complete its NEPA review before issuing the final rule.

E. Review Under Executive Order 13132

E.O. 13132, "Federalism," 64 FR 43255 (August 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 proposed rule and has tentatively determined that it would not have a substantial direct effect on the States, on the relationship between the national government and the States, or on the distribution of power and responsibilities among the various levels of government. EPCA governs and prescribes Federal preemption of State regulations as to energy conservation for the products that are the subject of this proposed rule. States can petition DOE for exemption from such preemption to the extent, and based on criteria, set forth in EPCA. (42 U.S.C. 6297) Therefore, no further action is required by Executive Order 13132.

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 Executive Order 12988 requires executive agencies to review regulations in light of applicable standards in section 3(a) and section 3(b) to determine whether they are met or it is unreasonable to meet one or more of them. DOE has completed the required review and determined that, to the extent permitted by law, this proposed 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, section 201 (codified at 2 U.S.C. 1531). For a proposed regulatory action likely to result in a rule that may cause the expenditure by State, local, and Tribal governments, in the aggregate, or by the private sector of $100 million or more in any one year (adjusted annually for inflation), section 202 of UMRA requires a Federal agency to publish a written statement that estimates the resulting costs, benefits, and other effects on the national economy. (2 U.S.C. 1532(a), (b)) The UMRA also requires a Federal agency to develop an effective process to permit timely input by elected officers of State, local, and Tribal governments on a proposed "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*.

Although this proposed rule does not contain a Federal intergovernmental mandate, it may require expenditures of $100 million or more in any one year by the private sector. Such expenditures may include: (1) investment in research and development and in capital expenditures by consumer boilers manufacturers in the years between the final rule and the compliance date for the newly amended standards and (2) incremental additional expenditures by consumers to purchase higher-efficiency consumer boilers, starting at the compliance date for the applicable standard.

Section 202 of UMRA authorizes a Federal agency to respond to the content requirements of UMRA in any other statement or analysis that accompanies the proposed rule. (2 U.S.C. 1532(c)) The content requirements of section 202(b) of UMRA relevant to a private sector mandate substantially overlap the economic analysis requirements that apply under section 325(o) of EPCA and Executive Order 12866. The **SUPPLEMENTARY INFORMATION** section of this NOPR and the TSD for this proposed rule respond to those requirements.

Under section 205 of UMRA, the Department is obligated to identify and consider a reasonable number of regulatory alternatives before promulgating a rule for which a written statement under section 202 is required. (2 U.S.C. 1535(a)) DOE is required to select from those alternatives the most cost-effective and least burdensome alternative that achieves the objectives of the proposed rule unless DOE publishes an explanation for doing otherwise, or the selection of such an alternative is inconsistent with law. As required by 42 U.S.C. 6295(m), this proposed rule would establish amended energy conservation standards for consumer boilers that are designed to achieve the maximum improvement in energy efficiency that DOE has determined to be both technologically feasible and economically justified, as required by 42 U.S.C. 6295(o)(2)(A) and 42 U.S.C. 6295(o)(3)(B). A full discussion of the alternatives considered by DOE is presented in chapter 17 of the TSD for this proposed rule.

H. Review Under the Treasury and General Government Appropriations Act, 1999

Section 654 of the Treasury and General Government Appropriations Act, 1999 (Pub. L. 105-277) requires Federal agencies to issue a Family Policymaking Assessment for any rule that may affect family well-being. This proposed 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 proposed 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 NOPR 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 proposed significant energy action. A "significant energy action" is defined as any action by an agency that promulgates or is expected to lead to promulgation of a final rule, and that: (1) is a significant regulatory action under Executive Order 12866, or any successor order; and (2) is likely to have a significant adverse effect on the supply, distribution, or use of energy, or (3) is designated by the Administrator of OIRA as a significant energy action. For any proposed 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 tentatively concluded that this regulatory action, which proposes amended energy conservation standards for consumer boilers, is not a significant energy action because the proposed 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 for this proposed rule.

L. Review Under the Information Quality Bulletin for Peer Review

On December 16, 2004, OMB, in consultation with the Office of Science and Technology Policy (OSTP), issued its Final Information Quality Bulletin for Peer Review (the Bulletin). 70 FR 2664 (Jan. 14, 2005). The Bulletin establishes that certain scientific information shall be peer reviewed by qualified specialists before it is disseminated by the Federal Government, including influential scientific information related to agency regulatory actions. The purpose of the bulletin is to enhance the quality and credibility of the Government's scientific information. Under the Bulletin, the energy conservation standards rulemaking analyses are "influential scientific information," which the Bulletin defines as "scientific information the agency reasonably can determine will have, or does have, a clear and substantial impact on important public policies or private sector decisions." *Id.* at 70 FR 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 has prepared a Peer Review report pertaining to the energy conservation standards rulemaking analyses.[175] 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

[175] 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 Jan. 3, 2023).

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 the Department's analyses. DOE is in the process of evaluating the resulting December 2021 NAS report.[176]

VII. Public Participation

A. Participation in the Public Meeting Webinar

The time and date of the webinar meeting are listed in the **DATES** section at the beginning of this document. Webinar registration information, participant instructions, and information about the capabilities available to webinar participants will be published on DOE's website: *www.energyenergy.gov/eere/buildings/public-meetings-and-comment-deadlines*. Participants are responsible for ensuring their systems are compatible with the webinar software.

B. Procedure for Submitting Prepared General Statements for Distribution

Any person who has plans to present a prepared general statement may request that copies of his or her statement be made available at the public meeting. Such persons may submit requests, along with an advance electronic copy of their statement in PDF (preferred), Microsoft Word or Excel, WordPerfect, or text (ASCII) file format, to the appropriate address shown in the **ADDRESSES** section at the beginning of this document. The request and advance copy of statements must be received at least one

[176] The December 2021 NAS report is available at *www.nationalacademies.org/our-work/review-of-methods-for-setting-building-and-equipment-performance-standards* (Last accessed Jan. 3, 2023).

week before the public meeting and are to be emailed. Please include a telephone number to enable DOE staff to make follow-up contact, if needed.

C. Conduct of the Webinar

DOE will designate a DOE official to preside at the webinar and may also use a professional facilitator to aid discussion. The meeting will not be a judicial or evidentiary-type public hearing, but DOE will conduct it in accordance with section 336 of EPCA (42 U.S.C. 6306). A court reporter will be present to record the proceedings and prepare a transcript. DOE reserves the right to schedule the order of presentations and to establish the procedures governing the conduct of the webinar/public meeting. There shall not be discussion of proprietary information, costs or prices, market share, or other commercial matters regulated by U.S. anti-trust laws. After the webinar and until the end of the comment period, interested parties may submit further comments on the proceedings and any aspect of the proposed rulemaking.

The webinar will be conducted in an informal, conference style. DOE will present a general overview of the topics addressed in this proposed rulemaking, allow time for prepared general statements by participants, and encourage all interested parties to share their views on issues affecting this proposed rulemaking. Each participant will be allowed to make a general statement (within time limits determined by DOE), before the discussion of specific topics. DOE will permit, as time permits, other participants to comment briefly on any general statements.

At the end of all prepared statements on a topic, DOE will permit participants to clarify their statements briefly. Participants should be prepared to answer questions by DOE and by other participants concerning these issues. DOE representatives may also ask questions of participants concerning other matters relevant to this proposed rulemaking. The official conducting the webinar will accept additional comments or questions from those attending, as time permits. The presiding official will announce any further procedural rules or modification of the above procedures that may be needed for the proper conduct of the webinar.

A transcript of the webinar will be included in the docket, which can be viewed as described in the *Docket* section at the beginning of this NOPR. In addition, any person may buy a copy of the transcript from the transcribing reporter.

D. Submission of Comments

DOE will accept comments, data, and information regarding this proposed rule before or after the public meeting webinar, but no later than the date provided in the **DATES** section at the beginning of this proposed rule. Interested parties may submit comments, data, and other information using any of the methods described in the **ADDRESSES** section at the beginning of this document.

Submitting comments via www.regulations.gov. The *www.regulations.gov* webpage will require you to provide your name and contact information. Your contact information will be viewable to DOE Building Technologies staff only. Your contact information will not be publicly viewable except for your first and last names, organization name (if any), and submitter representative name (if any). If your comment is not processed properly because of technical difficulties, DOE will use this information to contact you. If DOE cannot read your comment due to technical difficulties and cannot contact you for clarification, DOE may not be able to consider your comment.

However, your contact information will be publicly viewable if you include it in the comment itself or in any documents attached to your comment. Any information that you do not want to be publicly viewable should not be included in your comment, nor in any document attached to your comment. Otherwise, persons viewing comments will see only first and last names, organization names, correspondence containing comments, and any documents submitted with the comments.

Do not submit to *www.regulations.gov* information for which disclosure is restricted by statute, such as trade secrets and commercial or financial information (hereinafter referred to as Confidential Business Information (CBI)). Comments submitted through *www.regulations.gov* cannot be claimed as CBI. Comments received through the website will waive any CBI claims for the information submitted. For information on submitting CBI, see the Confidential Business Information section.

DOE processes submissions made through *www.regulations.gov* before posting. Normally, comments will be posted within a few days of being submitted. However, if large volumes of comments are being processed simultaneously, your comment may not be viewable for up to several weeks. Please keep the comment tracking number that *www.regulations.gov* provides after you have successfully uploaded your comment.

Submitting comments via email, hand delivery/courier, or postal mail. Comments and documents submitted via email, hand delivery/courier, or postal mail also will be posted to *www.regulations.gov*. If you do not want your personal contact information to be publicly viewable, do not include it in your comment or any accompanying documents. Instead, provide your contact information in a cover letter. Include your first and last names, email address, telephone number, and optional mailing address. The cover letter will not be publicly viewable as long as it does not include any comments.

Include contact information each time you submit comments, data, documents, and other information to DOE. If you submit via postal mail or hand delivery/courier, please provide all items on a CD, if feasible, in which case it is not necessary to submit printed copies. No telefacsimiles (faxes) will be accepted.

Comments, data, and other information submitted to DOE electronically should be provided in PDF (preferred), Microsoft Word or Excel, WordPerfect, or text (ASCII) file format. Provide documents that are not secured, that are written in English, and that are free of any defects or viruses. Documents should not contain special characters or any form of encryption, and, if possible, they should carry the electronic signature of the author.

Campaign form letters. Please submit campaign form letters by the originating organization in batches of between 50 to 500 form letters per PDF or as one form letter with a list of supporters' names compiled into one or more PDFs. This reduces comment processing and posting time.

Confidential Business Information. Pursuant to 10 CFR 1004.11, any person submitting information that he or she believes to be confidential and exempt by law from public disclosure should submit via email two well-marked copies: one copy of the document marked "confidential" including all the information believed to be confidential, and one copy of the document marked "non-confidential" with the information believed to be confidential deleted. DOE will make its own determination about the confidential status of the information and treat it according to its determination.

It is DOE's policy that all comments may be included in the public docket, without change and as received, including any personal information provided in the comments (except information deemed to be exempt from public disclosure).

E. Issues on Which DOE Seeks Comment

Although DOE welcomes comments on any aspect of this proposal, DOE is particularly interested in receiving comments and views of interested parties concerning the following issues:

1. DOE requests comment on the methodology used to present the change in producer cashflow (INPV) in the monetized benefits and cost tables I.3, I.4, and V.37 of this document.

2. DOE requests information on the market share of weatherized consumer boilers and the typical jacket losses of such products.

3. DOE requests further information on the potential future adoption of hydrogen-ready consumer boilers in the United States and any data demonstrating potential impacts of these burner systems on AFUE.

4. DOE requests comment on the tentative determination that condensing operation in oil-fired hot water boilers, pulse combustion, burner derating, low-pressure air-atomized oil burners, and control relays for models with BPM motors should be screened out from further analysis.

5. DOE requests comment on whether an increase in MPCs for gas-fired steam, oil-fired hot water, and oil-fired steam boilers would result from an amended standard requiring condensing technology for gas-fired hot water boilers and, if so, how much of an increase would occur. DOE also requests comment on whether the potential increase

in cast-iron boiler MPCs would only be applicable to consumer boiler manufacturers that operate their own foundries.

6. DOE requests comment on the cost-efficiency results in this engineering analysis. DOE also seeks input on the design options that would be implemented to achieve the selected efficiency levels.

7. DOE requests comment on DOE's space heating and water heating energy use methodology. DOE would also appreciate feedback, information, and data on these additional system types and processes that use consumer boilers (such as snow melt systems, pool or spa heating, or steam or hot water production for industrial or commercial processes).

8. DOE requests comment on DOE's methodology for determining the fraction of consumer boilers used in commercial buildings. DOE also seeks input regarding the fraction of consumer boilers in commercial buildings larger than 10,000 square feet.

9. DOE requests comments, information, and data regarding the relationship between boiler efficiency and return water temperature.

10. DOE requests comment on DOE's updated methodology for determining energy use for condensing boilers in different return water temperature applications.

11. DOE requests comments, information, and data showing the relationship between boiler efficiency and excess air during AFUE testing and in the field.

12. DOE requests comments on the default constant price trend for consumer boilers. DOE seeks comments on how material prices and technological advancement would be expected to impact future prices of consumer boilers.

13. DOE requests comments on its approach for taking into account electrification efforts in its shipment analysis. DOE also requests comments on other local, State, and Federal policies that may impact the shipments projection of consumer boilers.

14. DOE requests comments on its approach for developing efficiency trends beyond 2030.

15. DOE requests comments and any data on the potential for direct rebound.

16. DOE requests comments on its approach to monetizing the impact of the rebound effect.

17. DOE seeks comments, information, and data on the capital conversion costs and product conversion costs estimated for each TSL.

18. DOE seeks comments, information, and data on the potential direct employment impacts estimated for each TSL.

19. DOE seeks comment on whether manufacturers expect that manufacturing capacity or engineering resource constraints would limit product availability to consumers in the timeframe of the amended standards compliance date (2030).

20. DOE requests comment on the $20 per-unit reallocation cost for gas-fired steam, oil-fired hot water, and oil-fired steam boilers under a condensing standard for gas-fired hot water boilers, as well as the methodology used to derive the estimate.

21. DOE requests comment on the potential impacts on consumer boiler manufacturers that own domestic foundry assets including impacts but not limited to those vital to national security or critical infrastructure at the TSLs analyzed in this NOPR analysis.

22. DOE requests information regarding the impact of cumulative regulatory burden on manufacturers of consumer boilers associated with multiple DOE standards or product-specific regulatory actions of other Federal agencies in addition to state or local regulations.

23. DOE seeks comments, information, and data on the number of small businesses in the industry, the names of those small businesses, and their market shares by product class. DOE also requests comment on the potential impacts of the proposed standards on small manufacturers.

Additionally, DOE welcomes comments on other issues relevant to the conduct of this rulemaking that may not specifically be identified in this document.

VIII. Approval of the Office of the Secretary

The Secretary of Energy has approved publication of this notice of proposed rulemaking and request for comment.

List of Subjects in 10 CFR Part 430

Administrative practice and procedure, Confidential business information, Energy conservation, Household appliances, Imports, Intergovernmental relations, Reporting and recordkeeping requirements, Small businesses.

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

Digitally signed by FRANCISCO MORENO
Date: 2023.07.27 17:16:52 -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 proposes to amend part 430 of chapter II, subchapter D, of title 10 of the Code of Federal Regulations, as set forth below:

PART 430 -- ENERGY CONSERVATION PROGRAM FOR CONSUMER PRODUCTS

1. The authority citation for part 430 continues to read as follows:

Authority: 42 U.S.C. 6291-6309; 28 U.S.C. 2461 note.

2. Amend §430.32 by revising paragraph (e)(2) to read as follows:

§430.32 Energy and water conservation standards and their compliance dates.

* * * * *

(e)* * *

(2) *Boilers.*

(i) Except as provided in paragraph (e)(2)(iii) of this section, residential boilers manufactured on and after January 15, 2021, and before [*date 5 years after publication of the final rule in the Federal Register*], shall comply with the requirements as follows:

Product Class	Minimum AFUE[1] (percent)	Maximum $P_{W,SB}$[2] (Watts)	Maximum $P_{W,OFF}$[3] (Watts)	Design Requirements[4]
Gas-fired Hot Water	84	9	9	Constant-burning pilot not permitted. Automatic means for adjusting water temperature required (except for boilers equipped with tankless domestic water heating coils).
Gas-Fired Steam	82	8	8	Constant-burning pilot not permitted.
Oil-fired Hot Water	86	11	11	Automatic means for adjusting temperature required (except for boilers equipped with tankless domestic water heating coils).
Oil-fired Steam	85	11	11	None.
Electric Hot Water	None	8	8	Automatic means for adjusting temperature required (except for boilers equipped with tankless domestic water heating coils).
Electric Steam	None	8	8	None.

1 Annual Fuel Utilization Efficiency, as determined in §430.23(n)(2) of this part.
2 Standby Mode Power Consumption, as determined in appendix EE to subpart B of this part.
3 Off Mode Power Consumption, as determined in appendix EE to subpart B of this part.
4 See paragraph (e)(2)(iv) of this section.

(ii) Except as provided in paragraph (e)(2)(iii) of this section, residential boilers manufactured on and after [*date five years after publication of the final rule amending standards*], shall comply with the requirements as follows:

Product Class	Minimum AFUE[1] (percent)	Maximum $P_{W,SB}$[2] (Watts)	Maximum $P_{W,OFF}$[3] (Watts)	Design Requirements[4]
Gas-fired Hot Water	95	9	9	Constant-burning pilot not permitted. Automatic means for adjusting water temperature required (except for boilers equipped with tankless domestic water heating coils).
Gas-Fired Steam	82	8	8	Constant-burning pilot not permitted.
Oil-fired Hot Water	88	11	11	Automatic means for adjusting temperature required (except for boilers equipped with tankless domestic water heating coils).
Oil-fired Steam	86	11	11	None.
Electric Hot Water	None	8	8	Automatic means for adjusting temperature required (except for boilers equipped with tankless domestic water heating coils).
Electric Steam	None	8	8	None.

1 Annual Fuel Utilization Efficiency, as determined in §430.23(n)(2) of this part.
2 Standby Mode Power Consumption, as determined in appendix EE to subpart B of this part.
3 Off Mode Power Consumption, as determined in appendix EE to subpart B of this part.
4 See paragraph (e)(2)(iv) of this section.

(iii) A boiler that is manufactured to operate without any need for electricity or any electric connection, electric gauges, electric pumps, electric wires, or electric devices is not required to meet the AFUE or design requirements in paragraphs (e)(2)(i) or (2)(ii) of this section, but must meet the following requirements, as applicable:

Product class	**Minimum AFUE[1] (percent)**
Gas-fired Steam	75
Boilers Other Than Gas-fired Steam	80

1 Annual Fuel Utilization Efficiency, as determined in §430.23(n)(2) of this part.

(iv) *Automatic means for adjusting water temperature.*

(A) The automatic means for adjusting water temperature as required under paragraphs (e)(2)(i) and (2)(ii) of this section must automatically adjust the temperature of the water supplied by the boiler to ensure that an incremental change in inferred heat load produces a corresponding incremental change in the temperature of water supplied.

(B) For boilers that fire at a single input rate, the automatic means for adjusting water temperature requirement may be satisfied by providing an automatic means that allows the burner or heating element to fire only when the means has determined that the inferred heat load cannot be met by the residual heat of the water in the system.

(C) When there is no inferred heat load with respect to a hot water boiler, the automatic means described in this paragraph shall limit the temperature of the water in the boiler to not more than 140 degrees Fahrenheit.

(D) A boiler for which an automatic means for adjusting water temperature is required shall be operable only when the automatic means is installed.

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