DEPARTMENT OF ENERGY

10 CFR Part 431

[EERE–2021–BT–STD–0027]

RIN 1904–AD34

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

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

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

SUMMARY: The Energy Policy and Conservation Act, as amended (''EPCA''), prescribes energy conservation standards for certain commercial and industrial equipment, including commercial water heaters, hot water supply boilers, and unfired hot water storage tanks (hereinafter referred to as ''commercial water heating (CWH) equipment''). EPCA requires the U.S. Department of Energy (''DOE'') to periodically determine whether more-stringent standards for CWH equipment would be technologically feasible and economically justified, and would result in significant energy savings. In this notice of proposed rulemaking (''NOPR''), DOE proposes to amend the standards for certain classes of CWH equipment for which DOE has tentatively determined there is clear and convincing evidence to support more-stringent standards. Additionally, DOE is proposing to codify standards for electric instantaneous CWH equipment from EPCA into the Code of Federal Regulations (''CFR''). DOE also announces a public meeting to receive comment on these proposed standards and the associated analyses and results.

DATES:

Comments: DOE will accept comments, data, and information regarding this NOPR no later than July 18, 2022.

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 July 18, 2022.

Meeting: DOE will hold a public meeting via webinar on June 23, 2022, from 1:00 p.m. to 5:00 p.m. See section VII, ''Public Participation,'' for webinar registration information, participant instructions and information about the capabilities available to webinar participants.

ADDRESSES: Interested persons are encouraged to submit comments using the Federal eRulemaking Portal at *www.regulations.gov*. Follow the instructions for submitting comments. Alternatively, interested persons may submit comments, identified by docket number EERE–2021–BT–STD–0027 and/or regulatory information number (RIN) 1904–AD34, by any of the following methods:

(1) *Federal eRulemaking Portal: www.regulations.gov*. Follow the instructions for submitting comments.

(2) *Email: Mail to: CommWaterHeaters2021STD0027@ee.doe.gov*. Include the docket number EERE–2021–BT–STD–0027 in the subject line of the message.

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

Although DOE has routinely accepted public comment submissions through a variety of mechanisms, including the Federal eRulemaking Portal, email, postal mail and hand delivery/courier, the Department has found it necessary to make temporary modifications to the comment submission process in light of the ongoing coronavirus 2019 (''COVID–19'') pandemic. DOE is currently suspending receipt of public comments via postal mail and hand delivery/courier. If a commenter finds that this change poses an undue hardship, please contact Appliance Standards Program staff at (202) 586–1445 to discuss the need for alternative arrangements. Once the COVID–19 pandemic health emergency is resolved, DOE anticipates resuming all of its regular options for public comment submission, including postal mail and hand delivery/courier.

Docket: The docket for this rulemaking, 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, some documents listed in the index, such as those containing information that is exempt from public disclosure, may not be publicly available.

The docket webpage can be found at *www.regulations.gov/docket/EERE-2021-BT-STD-0027*. The docket webpage contains instructions on how to access all documents, including public comments, in the docket. See section VII, ''Public Participation,'' for information on how to submit comments through *www.regulations.gov*.

Written comments regarding the burden-hour estimates or other aspects of the collection-of-information requirements contained in this proposed rule may be submitted to Office of Energy Efficiency and Renewable Energy following the instructions at *www.reginfo.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 (''DOJ'') Antitrust Division invites input from market participants and other interested persons with views on the likely competitive impact of the proposed standard. 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. Matthew Ring, U.S. Department of Energy, Office of the General Counsel, GC–33, 1000 Independence Avenue SW, Washington, DC 20585–0121. Telephone: (202) 586–2555. Email: *Matthew.Ring@hq.doe.gov*.

DOE has submitted the collection of information contained in the proposed rule to OMB for review under the Paperwork Reduction Act, as amended. (44 U.S.C. 3507(d)) Comments on the information collection proposal shall be directed to the Office of Information and Regulatory Affairs, Office of Management and Budget, Attention: Sofie Miller, OIRA Desk Officer by email: *sofie.e.miller@omb.eop.gov*.

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

SUPPLEMENTARY INFORMATION: DOE proposes to update previously approved incorporations by reference of the following industry standards in part 431:

ASTM C177–13, ''Standard Test Method for Steady-State Heat Flux Measurements and Thermal Transmission Properties by Means of the Guarded-Hot-Plate Apparatus,'' approved September 15, 2013.

ASTM C518–15, ''Standard Test Method for Steady-State Thermal Transmission Properties by Means of the Heat Flow Meter Apparatus,'' approved September 1, 2015.

Copies of ASTM C177–13 and ASTM C518–15 can be obtained from ASTM International, 100 Barr Harbor Drive, P.O. Box C700, West Conshohocken, PA 19428–2959, (610) 832–9585, or go to *www.astm.org*.

For a further discussion of these standards, see section VI.M of this document.

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I. Synopsis of the Proposed Rule

Title III, Part C[1] of EPCA,[2] established the Energy Conservation Program for Certain Industrial Equipment. (42 U.S.C. 6311–6317) Such equipment includes CWH equipment, the subject of this NOPR. (42 U.S.C. 6311(1)(K))

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

In accordance with these and other statutory provisions discussed in this document, DOE proposes amended energy conservation standards for certain classes of CWH equipment. The proposed standards, which are expressed in terms of thermal efficiency, standby loss, and uniform energy factor (''UEF''), are shown in Table I.1 and Table I.2. These proposed standards, if adopted, would apply to all CWH equipment listed in Table I.1 and Table I.2, manufactured in, or imported into the United States starting on the date 3 years after the publication of the final rule for this rulemaking. DOE is also proposing to codify standards for electric instantaneous CWH equipment from EPCA into the CFR. Finally, DOE is proposing several changes to the footnotes to tables of energy conservation standards at 10 CFR 431.110 to clarify existing regulations for CWH equipment. The proposed standards for electric instantaneous CWH equipment and changes to the footnotes are also shown in Table I.1.

TABLE I.1—PROPOSED ENERGY CONSERVATION STANDARDS FOR COMMERCIAL WATER HEATING EQUIPMENT EXCEPT FOR RESIDENTIAL-DUTY COMMERCIAL WATER HEATERS

Equipment	Size	Energy conservation standards *	
		Minimum thermal efficiency (%)	Maximum standby loss †
Gas-fired storage water heaters	All	95	$0.86 \times [Q/800 + 110(V_r)^{1/2}]$ (Btu/h).
Electric instantaneous water heaters ‡	<10 gal	80	N/A.
	≥10 gal	77	$2.30 + 67/V_m$ (%/h).
Gas-fired instantaneous water heaters and hot water supply boilers	<10 gal	96	N/A.
	≥10 gal	96	$Q/800 + 110(V_r)^{1/2}$ (Btu/h).

* V_m is the measured storage volume, and V_r is the rated volume, both in gallons. Q is the rated input rate in Btu/h, as determined pursuant to 10 CFR 429.44.

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

‡ Energy conservation standards for electric instantaneous water heaters are included in EPCA. (42 U.S.C. 6313(a)(5)(D)–(E)) The compliance date for these energy conservation standards is January 1, 1994. In this NOPR, DOE proposes to codify these standards for electric instantaneous water heaters in its regulations at 10 CFR 431.110. Further discussion of standards for electric instantaneous water heaters is included in section III.B.4 of this NOPR.

TABLE I.2—PROPOSED AMENDED ENERGY CONSERVATION STANDARDS FOR GAS-FIRED RESIDENTIAL-DUTY COMMERCIAL WATER HEATERS

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

* Additionally, to be classified as a residential-duty water heater, a commercial water heater must meet the following conditions: (1) If requiring electricity, use single-phase external power supply; and (2) the water heater must not be designed to heat water at temperatures greater than 180 °F.

** Draw pattern is a classification of hot water use of a consumer water heater or residential-duty commercial water heater, based upon the first-hour rating. The draw pattern is determined using the *Uniform Test Method for Measuring the Energy Consumption of Water Heaters* in appendix E to subpart B of 10 CFR part 430.

† V_r is the rated storage volume (in gallons), as determined pursuant to 10 CFR 429.44.

A. Benefits and Costs to Consumers

Table I.3 presents DOE's evaluation of the economic impacts of the proposed standards on consumers of CWH equipment, as measured by the average life-cycle cost (''LCC'') savings and the simple payback period (''PBP'').[3] The average LCC savings are positive for all equipment classes, and the PBP is less than the average lifetime of CWH equipment, which is estimated to range from 10 years for commercial gas-fired storage water heaters to 25 years for instantaneous water heaters and hot water supply boilers (see section IV.F.2.g of this document).

[1] For editorial reasons, upon codification in the U.S. Code, Part C was re-designated Part A–1.

[2] All references to EPCA in this document refer to the statute as amended through the Energy Act of 2020, Public Law 116–260 (Dec. 27, 2020).

[3] The average LCC savings refer to consumers that are affected by a standard and are measured relative to the efficiency distribution in the no-new-standards case, which depicts the market in the compliance year in the absence of new or amended standards (see section IV.F.2.i of this document). The simple PBP, which is designed to compare specific efficiency levels, is measured relative to the baseline product (see section IV.F.3 of this document).

TABLE I.3—IMPACTS OF PROPOSED ENERGY CONSERVATION STANDARDS ON CONSUMERS OF CWH EQUIPMENT

Equipment	Average LCC savings (2020$)	Simple payback period (years)
Commercial Gas-Fired Storage and Storage-Type Instantaneous	301	5
Residential-Duty Gas-Fired Storage	90	9
Gas-Fired Instantaneous Water Heaters and Hot Water Supply Boilers	599	9
—Instantaneous, Gas-Fired Tankless	63	9
—Instantaneous Water Heaters and Hot Water Supply Boilers	1,047	9

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

B. Impact on Manufacturers

The industry net present value (''INPV'') is the sum of the discounted cash flows to the industry from the base year through the end of the analysis period (2020–2055). Using a real discount rate of 9.1 percent, DOE estimates that the INPV for manufacturers of CWH Equipment in the case without amended standards is $183.1 million in 2020$. Under the proposed standards, the change in INPV is estimated to range from −12.8 percent to −5.9 percent, which is approximately equivalent to a decrease of $23.4 million to a decrease of $10.8 million, respectively. In order to bring products into compliance with amended standards, it is estimated that the industry would incur total conversion costs of $34.6 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[4]

DOE's analyses indicate that the proposed energy conservation standards for CWH equipment would save a significant amount of energy. Relative to the case without amended standards, the lifetime energy savings for CWH Equipment purchased in the 30-year period that begins in the anticipated year of compliance with the amended standards (2026–2055) amount to 0.70 quadrillion British thermal units (''Btu''), or quads.[5] This represents a savings of 4.9 percent relative to the energy use of these products in the case without amended standards (referred to as the ''no-new-standards case'').

The cumulative net present value (''NPV'') of total consumer benefits of the proposed standards for CWH equipment ranges from $0.48 billion (at a 7-percent discount rate) to $1.49 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 CWH equipment purchased in 2026–2055.

In addition, the proposed standards for CWH equipment 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 38 million metric tons (''Mt'')[6] of carbon dioxide (''CO_2''), −0.02 thousand tons of sulfur dioxide (''SO_2''), 95 thousand tons of nitrogen oxides (''NO_X''), 471 thousand tons of methane (''CH_4''), 0.07 thousand tons of nitrous oxide (''N_2O''), and −0.001 tons of mercury (''Hg'').[7]

DOE estimates climate benefits from a reduction in greenhouse gases using four different estimates of the ''social cost of carbon'' (''SC-CO_2''), the social cost of methane (''SC-CH_4''), and the social cost of nitrous oxide (''SC-N_2O''). Together these represent the social cost of greenhouse gases (''SC-GHG''). DOE used interim estimates of SC-GHG values developed by an Interagency Working Group on the Social Cost of Greenhouse Gases (IWG).[8] The derivation of these values is discussed in section IV.L.1. of this document. For presentational purposes, the climate benefits associated with the average SC-GHG at a 3-percent discount rate is $1.96 billion. DOE does not have a single central SC-GHG point estimate and it emphasizes the importance and value of considering the benefits calculated using all four SC-GHG estimates.[9]

DOE also estimates the health benefits from SO_2 and NO_X emissions reduction.[10] DOE estimates the present value of the health benefits would be $0.99 billion using a 7-percent discount rate, and $2.62 billion using a 3-percent discount. DOE is currently only monetizing fine particulate matter (''$PM_{2.5}$'') and (for NO_X) ozone precursor health benefits, but will continue to assess the ability to monetize other effects such as health benefits from reductions in direct $PM_{2.5}$ emissions.

Table I.4 summarizes the economic benefits and costs expected to result from the proposed standards for CWH equipment. In the table, total benefits for both the 3-percent and 7-percent cases are presented using the average GHG social costs with 3-percent discount rate. DOE does not have a

[4] All monetary values in this document are expressed in 2020 dollars.

[5] The quantity refers to full-fuel-cycle (''FFC'') energy savings. FFC energy savings include the energy consumed in extracting, processing, and transporting primary fuels (*i.e.,* coal, natural gas, petroleum fuels), and, thus, presents a more complete picture of the impacts of energy efficiency standards. For more information on the FFC metric, see section IV.H.3 of this document.

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

[7] DOE calculated emissions reductions relative to the no-new-standards case, which reflects key assumptions in the *Annual Energy Outlook 2021* (''*AEO2021*''). *AEO2021* represents current Federal and State legislation and final implementation of regulations as of the time of its preparation. See section IV.K for further discussion of *AEO2021* assumptions that effect air pollutant emissions.

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

[9] On March 16, 2022, the Fifth Circuit Court of Appeals (No. 22–30087) granted the Federal Government's emergency motion for stay pending appeal of the February 11, 2022, preliminary injunction issued in *Louisiana* v. *Biden,* No. 21–cv–1074–JDC–KK (W.D. La.). As a result of the Fifth Circuit's order, the preliminary injunction is no longer in effect, pending resolution of the Federal Government's appeal of that injunction or a further court order. Among other things, the preliminary injunction enjoined the defendants in that case from ''adopting, employing, treating as binding, or relying upon'' the interim estimates of the social cost of greenhouse gases—which were issued by the Interagency Working Group on the Social Cost of Greenhouse Gases on February 26, 2021—to monetize the benefits of reducing greenhouse gas emissions. In the absence of further intervening court orders, DOE will revert to its approach prior to the injunction and present monetized benefits where appropriate and permissible under law.

[10] DOE estimated the monetized value of SO_2 and NO_X emissions reductions associated with site and electricity savings using benefit per ton estimates from the scientific literature. See section IV.L.2 of this document for further discussion.

single central SC-GHG point estimate and it emphasizes the importance and value of considering the benefits calculated using all four SC-GHG estimates. The estimated total net benefits using each of the four SC-GHG estimates are presented in section V.B.6. of this document.

TABLE I.4—SUMMARY OF ECONOMIC BENEFITS AND COSTS OF PROPOSED ENERGY CONSERVATION STANDARDS FOR CWH EQUIPMENT

[TSL 3]

	Billion 2020$
3% Discount Rate	
Consumer Operating Cost Savings	2.4
Climate Benefits *	2.0
Health Benefits **	2.6
Total Benefits †	7.0
Consumer Incremental Product Costs ‡	1.0
Net Benefits	6.1
7% Discount Rate	
Consumer Operating Cost Savings	1.0
Climate Benefits * (3% discount rate)	2.0
Health Benefits **	1.0
Total Benefits †	4.0
Consumer Incremental Product Costs ‡	0.6
Net Benefits	3.4

Note: This table presents the costs and benefits associated with commercial water heaters shipped in 2026–2055. These results include benefits to consumers which accrue after 2055 from the products shipped in 2026–2055. Numbers may not add due to rounding.

* Climate benefits are calculated using four different estimates of the social cost of carbon (SC-CO_2), methane (SC-CH_4), and nitrous oxide (SC-N_2O) (model average at 2.5 percent, 3 percent, and 5 percent discount rates; 95th percentile at 3 percent discount rate), as shown in Table V.37 through Table V.39. Together these represent the global social cost of greenhouse gases (SC-GHG). For presentational purposes of this table, the climate benefits associated with the average SC-GHG at a 3 percent discount rate are shown, but the Department does not have a single central SC-GHG point estimate. See section IV.L of this document for more details.

** Health benefits are calculated using benefit-per-ton values for NO_X and SO_2. DOE is currently only monetizing $PM_{2.5}$ and (for NO_X) ozone precursor health benefits, but will continue to assess the ability to monetize other effects such as health benefits from reductions in direct $PM_{2.5}$ emissions. The health benefits are presented at real discount rates of 3 and 7 percent. See section IV.L of this document for more details.

† Total and net benefits include consumer, climate, and health benefits. For presentation purposes, total and net benefits for both the 3-percent and 7-percent cases are presented using the average SC-GHG with 3-percent discount rate, 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 SC-GHG estimates. See Table V.42 for net benefits using all four SC-GHG estimates. On March 16, 2022, the Fifth Circuit Court of Appeals (No. 22–30087) granted the federal government's emergency motion for stay pending appeal of the February 11, 2022, preliminary injunction issued in *Louisiana* v. *Biden,* No. 21–cv–1074–JDC–KK (W.D. La.). As a result of the Fifth Circuit's order, the preliminary injunction is no longer in effect, pending resolution of the federal government's appeal of that injunction or a further court order. Among other things, the preliminary injunction enjoined the defendants in that case from "adopting, employing, treating as binding, or relying upon" the interim estimates of the social cost of greenhouse gases—which were issued by the Interagency Working Group on the Social Cost of Greenhouse Gases on February 26, 2021—to monetize the benefits of reducing greenhouse gas emissions. In the absence of further intervening court orders, DOE will revert to its approach prior to the injunction and present monetized benefits where appropriate and permissible under law.

‡ Costs include incremental equipment costs as well as installation costs.

The benefits and costs of the proposed standards can also be expressed in terms of annualized values. The monetary values for the total annualized net benefits are (1) the reduced consumer operating costs, minus (2) the increase in product purchase prices and installation costs, plus (3) the value of the benefits of GHG, NO_X, and SO_2 emission reductions, all annualized.[11]

The national operating savings are domestic private U.S. consumer monetary savings that occur as a result of purchasing the covered products and are measured for the lifetime of CWH equipment shipped in 2026–2055. The climate benefits associated with reduced GHG emissions achieved as a result of the proposed standards are also calculated based on the lifetime of CWH equipment shipped in 2026–2055.

Estimates of annualized benefits and costs of the proposed standards are shown in Table I.5. 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 SO_2 and NO_X emissions, and the 3-percent discount rate case for climate benefits from reduced GHG emissions, the estimated cost of the standards proposed in this rulemaking is $59 million per year in increased equipment costs, while the estimated annual benefits are $110 million in reduced equipment operating costs, $113 million in climate benefits, and $104 million in health benefits. In this case, the net benefit would amount to $267 million per year.

Using a 3-percent discount rate for all benefits and costs, the estimated cost of the proposed standards is $55 million per year in increased equipment costs, while the estimated annual benefits are $140 million in reduced operating costs, $113 million in climate benefits, and $150 million in health benefits. In this case, the net benefit would amount to $349 million per year.

[11] To convert the time-series of costs and benefits into annualized values, DOE calculated a present value in 2021, 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 2021. The calculation uses discount rates of 3 and 7 percent for all costs and benefits except for the value of CO_2 reductions, for which DOE used case-specific discount rates, as shown in Table I.3. Using the present value, DOE then calculated the fixed annual payment over a 30-year period, starting in the compliance year, that yields the same present value.

TABLE I.5—ANNUALIZED BENEFITS AND COSTS OF PROPOSED ENERGY CONSERVATION STANDARDS FOR CWH EQUIPMENT

[TSL 3]

Category	Million 2020$/year		
	Primary estimate	Low-net-benefits estimate	High-net-benefits estimate
3% Discount Rate			
Consumer Operating Cost Savings	140.3	130.3	151.7
Climate Benefits *	112.8	107.2	117.8
Health Benefits **	150.4	143.5	170.0
Total Benefits †	404	381	439
Consumer Incremental Product Costs ‡	54.7	52.6	56.6
Net Benefits	349	328	383
7% Discount Rate			
Consumer Operating Cost Savings	109.6	103.3	116.7
Climate Benefits * (3% discount rate)	112.8	107.2	117.8
Health Benefits **	104.3	100.4	117.2
Total Benefits †	327	311	352
Consumer Incremental Product Costs ‡	59.2	57.5	60.9
Net Benefits	267	253	291

Note: This table presents the annualized costs and benefits associated with CWH equipment shipped in 2026–2055. These results include benefits to consumers which accrue after 2055 from the products purchased in 2026–2055.

* Climate benefits are calculated using four different estimates of the social cost of carbon (SC-CO_2), methane (SC-CH_4), and nitrous oxide (SC-N_2O) (model average at 2.5 percent, 3 percent, and 5 percent discount rates; 95th percentile at 3 percent discount rate). Together these represent the global social cost of greenhouse gases (SC-GHG). For presentational purposes of this table, the climate benefits associated with the average SC-GHG at a 3 percent discount rate are shown, but the Department does not have a single central SC-GHG point estimate, and it emphasizes the importance and value of considering the benefits calculated using all four SC-GHG estimates. See section IV.L of this document for more details.

** Health benefits are calculated using benefit-per-ton values for NO_X and SO_2. DOE is currently only monetizing $PM_{2.5}$ and (for NO_X) ozone precursor health benefits, but will continue to assess the ability to monetize other effects such as health benefits from reductions in direct $PM_{2.5}$ emissions. The health benefits are presented at real discount rates of 3 and 7 percent. See section IV.L of this document for more details.

† Total and net benefits include consumer, climate, and health benefits. For presentation purposes, total and net benefits for both the 3-percent and 7-percent cases are presented using the average SC-GHG with 3-percent discount rate, 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 SC-GHG estimates. On March 16, 2022, the Fifth Circuit Court of Appeals (No. 22–30087) granted the federal government's emergency motion for stay pending appeal of the February 11, 2022, preliminary injunction issued in *Louisiana* v. *Biden,* No. 21–cv–1074–JDC–KK (W.D. La.). As a result of the Fifth Circuit's order, the preliminary injunction is no longer in effect, pending resolution of the federal government's appeal of that injunction or a further court order. Among other things, the preliminary injunction enjoined the defendants in that case from ''adopting, employing, treating as binding, or relying upon'' the interim estimates of the social cost of greenhouse gases—which were issued by the Interagency Working Group on the Social Cost of Greenhouse Gases on February 26, 2021—to monetize the benefits of reducing greenhouse gas emissions. In the absence of further intervening court orders, DOE will revert to its approach prior to the injunction and present monetized benefits where appropriate and permissible under law.

‡ Costs include incremental equipment costs as well as installation costs.

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, based on clear and convincing evidence as presented in the following sections, the proposed standards are technologically feasible and economically justified, and would result in the significant additional conservation of energy. Specifically, with regards to technological feasibility, CWH equipment achieving these standard levels are already commercially available for all equipment 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 cost of the proposed standards for CWH equipment is $59.2 million per year in increased equipment costs, while the estimated annual benefits are $109.6 million in reduced equipment operating costs, $112.8 million in GHG reductions, $104.6 million in reduced NO_X emissions, and −$0.30 million in (increased) SO_2 emissions. The net benefit amounts to $267.4 million per year.

As previously mentioned, the proposed standards would result in estimated national energy savings of 0.70 quad, the equivalent of the electricity use of 7.0 million homes in one year. In determining whether energy savings are significant, DOE considers the specific circumstances surrounding a given rulemaking.[12] In making this determination, DOE looks at, among other things, the FFC effects of the proposed standards. These effects include the energy consumed in electricity production (depending on load shape), in distribution and transmission, and in extracting, processing, and transporting primary fuels (*i.e.,* coal, natural gas, petroleum fuels), and thus present a more complete picture of the impacts of energy conservation standards, including greenhouse gas emissions. Accordingly, taking into account the significance of cumulative FFC national energy savings, the cumulative FFC emissions

[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).

reductions, and the need to confront the global climate crisis, among other factors, DOE has initially determined the energy savings for the TSL proposed in this rulemaking are ''significant'' within the meaning of EPCA. Finally, DOE notes that a more detailed discussion of the basis for these tentative conclusions is contained in the remainder of this document and the accompanying TSD. Based on available facts, data, and DOE's own analyses, DOE has preliminarily determined that it is highly probable an amended standard would result in a significant additional amount of energy savings, and is technologically feasible and economically justified.

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 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 NOPR, as well as some of the historical background relevant to the establishment of the amended standards for CWH equipment.

A. Authority

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

The energy conservation program for covered products under EPCA consists essentially of four parts: (1) Testing, (2) labeling, (3) the establishment of Federal energy conservation standards, and (4) certification and enforcement procedures. Relevant provisions of EPCA specifically include definitions (42 U.S.C. 6311), energy conservation standards (42 U.S.C. 6313), test procedures (42 U.S.C. 6314), labeling provisions (42 U.S.C. 6315), and the authority to require information and reports from manufacturers (42 U.S.C. 6316).

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

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

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

In deciding whether a more-stringent standard is economically justified, under either the provisions of 42 U.S.C. 6313(a)(6)(A) or 42 U.S.C. 6313(a)(6)(C), DOE must determine whether the benefits of the standard exceed its burdens. DOE must make this determination after receiving comments on the proposed standard, and by considering, to the maximum extent practicable, the following seven factors:

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

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

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

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

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

(6) The need for national energy conservation; and

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

[13] The clear and convincing threshold is a heightened standard, and would only be met where the Secretary has an abiding conviction, based on available facts, data, and DOE's own analyses, that it is highly probable an amended standard would result in a significant additional amount of energy savings, and is technologically feasible and economically justified. *American Public Gas Association* v. *U.S. Dep't of Energy,* No. 20–1068, 2022 WL 151923, at *4 (D.C. Cir. January 18, 2022) (citing *Colorado* v. *New Mexico,* 467 U.S. 310, 316, 104 S.Ct. 2433, 81 L.Ed.2d 247 (1984)).

(42 U.S.C. 6313(a)(6)(B)(ii)(I)–(VII))

Further, EPCA establishes a rebuttable presumption that an energy conservation standard is economically justified if the Secretary finds that the additional cost to the consumer of purchasing a product that complies with the standard will be less than three times the value of the energy (and, as applicable, water) savings during the first year that the consumer will receive as a result of the standard, as calculated under the applicable test procedure. (42 U.S.C. 6295(o)(2)(B)(iii)) However, while this rebuttable presumption analysis applies to most commercial and industrial equipment (42 U.S.C. 6316(a)), it is not a required analysis for ASHRAE equipment (42 U.S.C. 6316(b)(1)). Nonetheless, DOE included the analysis of rebuttable presumption in its economic analysis and presents the results in section V.B.1.c of this document.

EPCA also contains what is known as an ''anti-backsliding'' provision, which prevents the Secretary from prescribing any amended standard that either increases the maximum allowable energy use or decreases the minimum required energy efficiency of a covered product. (42 U.S.C. 6313(a)(6)(B)(iii)(I)) Also, the Secretary may not prescribe an amended or new standard if interested persons have established by a preponderance of the evidence that the standard is likely to result in the unavailability in the United States in any covered product type (or class) of performance characteristics (including reliability), features, sizes, capacities, and volumes that are substantially the same as those generally available in the United States. (42 U.S.C. 6313(a)(6)(B)(iii)(II)(aa))

B. Background and Rulemaking History

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

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

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

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

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

In ASHRAE Standard 90.1–2013, ASHRAE increased the thermal efficiency level for commercial oil-fired storage water heaters, thereby triggering DOE's statutory obligation to promulgate an amended uniform national standard at those levels, unless DOE were to determine that there is clear and convincing evidence supporting the adoption of more-stringent energy conservation standards than the ASHRAE levels.[14] In a final rule published on July 17, 2015 (''July 2015 ASHRAE equipment final rule''), among other things, DOE adopted the standard for commercial oil-fired storage water heaters at the level set forth in ASHRAE Standard 90.1–2013, which increased the standard from 78 to 80 percent thermal efficiency with compliance required starting on October 9, 2015. 80 FR 42614 (July 17, 2015). Since that time ASHRAE has issued 2 updated versions of Standard 90.1, 90.1–2016 and 90.1–2019. However, DOE was not triggered to review amended standards for commercial water heaters by any updates in ASHRAE Standard 90.1–2016 or ASHRAE Standard 90.1–2019. Overall, DOE has not been triggered to review the standards for the equipment subject to this rulemaking based on an update

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

to the efficiency levels in ASHRAE Standard 90.1 since the 1999 edition because ASHRAE has not updated the efficiency levels for such equipment since 1999. The current standards for all CWH equipment classes are set forth in DOE's regulations at 10 CFR 431.110, except for electric instantaneous water heaters that are not residential-duty, which are included in EPCA (the history of the standards for electric instantaneous water heaters is discussed in section III.B.4 of this document). (42 U.S.C. 6313(a)(5)(D)–(E)) Table II.1 shows the current standards for all CWH equipment classes, except residential-duty commercial water heaters, which are shown in Table II.2 of this document.

TABLE II.1—CURRENT FEDERAL ENERGY CONSERVATION STANDARDS FOR CWH EQUIPMENT EXCEPT FOR RESIDENTIAL-DUTY COMMERCIAL WATER HEATERS

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

* V_m is the measured storage volume, and V_r is the rated volume, both in gallons. Q is the nameplate input rate in Btu/h.
** For hot water supply boilers with a capacity of less than 10 gallons: (1) The standards are mandatory for products manufactured on and after October 21, 2005 and (2) products manufactured prior to that date, and on or after October 23, 2003, must meet either the standards listed in this table or the applicable standards in subpart E of this part for a "commercial packaged boiler."
*** For oil-fired storage water heaters: (1) The standards are mandatory for equipment manufactured on and after October 9, 2015 and (2) equipment manufactured prior to that date must meet a minimum thermal efficiency level of 78 percent.
† Water heaters and hot water supply boilers having more than 140 gallons of storage capacity need not meet the standby loss requirement if: (1) The tank surface area is thermally insulated to R–12.5 or more, (2) a standing pilot light is not used, and (3) for gas or oil-fired storage water heaters, they have a fire damper or fan-assisted combustion.
‡ Energy conservation standards for electric instantaneous water heaters are included in EPCA. (42 U.S.C. 6313(a)(5)(D)–(E)) The compliance date for these energy conservation standards is January 1, 1994. In this NOPR, DOE proposes to codify these standards for electric instantaneous water heaters in its regulations at 10 CFR 431.110. Further discussion of standards for electric instantaneous water heaters is included in section III.B.4 of this NOPR.

TABLE II.2—CURRENT ENERGY CONSERVATION STANDARDS FOR RESIDENTIAL-DUTY COMMERCIAL WATER HEATERS

Equipment	Specification *	Draw pattern **	Uniform energy factor	Compliance date
Gas-fired Storage	>75 kBtu/h and ≤105 kBtu/h and ≤120 gal	Very Small	$0.2674 - (0.0009 \times V_r)$	December 29, 2016.
		Low	$0.5362 - (0.0012 \times V_r)$.	
		Medium	$0.6002 - (0.0011 \times V_r)$.	
		High	$0.6597 - (0.0009 \times V_r)$.	
Oil-fired storage	>105 kBtu/h and ≤140 kBtu/h and ≤120 gal	Very Small	$0.2932 - (0.0015 \times V_r)$.	
		Low	$0.5596 - (0.0018 \times V_r)$.	
		Medium	$0.6194 - (0.0016 \times V_r)$.	
		High	$0.6740 - (0.0013 \times V_r)$.	
Electric instantaneous	>12 kW and ≤58.6 kW and ≤ 2 gal	Very Small	0.80.	
		Low	0.80.	
		Medium	0.80.	
		High	0.80.	

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

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

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

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

DOE received a number of comments from interested parties in response to the May 2016 CWH ECS NOPR. Table II.3 identifies these commenters. Although DOE withdrew the May 2016 CWH ECS NOPR (as discussed in the following paragraphs), DOE considered comments received in response to that document to the extent relevant to the preparation of this NOPR.

TABLE II.3—INTERESTED PARTIES PROVIDING WRITTEN AND ORAL COMMENTS ON THE MAY 2016 CWH ECS NOPR

Name	Abbreviation	Commenter type *
Appliance Standards Awareness Project, Alliance to Save Energy, Northeast Energy Efficiency Partnership, American Council for an Energy-Efficient Economy, EarthJustice.	Joint Advocates	EA
Northwest Energy Efficiency Alliance	NEEA	EA
Air-Conditioning, Heating and Refrigeration Institute	AHRI	TA
The U.S. Chamber of Commerce, the American Chemistry Council, the American Coke and Coal Chemicals Institute, the American Forest & Paper Association, the American Fuel & Petrochemical Manufacturers, the American Petroleum Institute, the Brick Industry Association, the Council of Industrial Boiler Owners, the National Association of Manufacturers, the National Mining Association, the National Oilseed Processors Association, and the Portland Cement Association.	The Associations	TA
Industrial Energy Consumers of America	IECA	TA
American Gas Association and American Public Gas Association	AGA and APGA	UA
Edison Electric Institute	EEI	UA
National Propane Gas Association	NPGA	IR
National Rural Electric Cooperative Association, American Public Power Association, Edison Electric Institute.	Joint Utilities	IR
Plumbing-Heating-Cooling Contractors National Association	PHCC	IR
A.O. Smith Corporation	A.O. Smith	M
Bock Water Heaters, Inc	Bock	M
Bradford White Corporation	Bradford White	M
HTP, Inc	HTP	M
Raypak, Inc	Raypak	M
Rheem Corporation	Rheem	M
California Energy Commission	CEC	OS
Environmental Defense Fund, Institute for Policy Integrity at New York University School of Law, Natural Resources Defense Council, and Union of Concerned Scientists.	Joint Organizations	OS
Pacific Gas and Electric Company, Southern California Gas Company, San Diego Gas and Electric, and Southern California Edison.	CA IOUs	U
Spire Inc	Spire	U
Anonymous	Anonymous	I
Johnnie Temples	Johnnie Temples	I
PVI Industries, Inc	PVI	M
NegaWatt Consulting	NegaWatt	OS
Bradley Corporation	Bradley	M

* TA: trade association, EA: efficiency/environmental advocate, IR: industry representative, M: manufacturer, OS: other stakeholder, U: utility or utilities filing jointly, UA: utility association, and I: individual.

A parenthetical reference at the end of a comment quotation or paraphrase provides the location of the item in the public record.[15]

[15] The parenthetical reference provides a reference for information located in the docket. (Docket No. EERE–2014–BT–STD–0042, which is maintained at *www.regulations.gov/#!docketDetail;D=EERE-2014-BT-STD-0042*). The references are arranged as follows: (commenter name, comment docket ID number, page of that document).

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

On January 15, 2021, in response to a petition for rulemaking submitted by the American Public Gas Association, Spire, Inc., the Natural Gas Supply Association, the American Gas Association, and the National Propane Gas Association (83 FR 54883; Nov. 1, 2018) DOE published a final interpretive rule (''the January 2021 final interpretive rule'') determining that, in the context of residential furnaces, commercial water heaters, and similarly-situated products/equipment, use of non-condensing technology (and associated venting) constitute a performance-related ''feature'' under EPCA that cannot be eliminated through adoption of an energy conservation standard. 86 FR 4776. Correspondingly, DOE withdrew the May 2016 CWH ECS NOPR. 86 FR 3873 (Jan. 15, 2021).

However, DOE has subsequently published a final interpretive rule that returns to the previous and long-standing interpretation (in effect prior to the January 15, 2021 final interpretive rule), under which the technology used to supply heated air or hot water is not a performance-related ''feature'' that provides a distinct consumer utility under EPCA. 86 FR 73947 (Dec. 29, 2021).

In conducting the analysis for this NOPR, DOE evaluates condensing technologies and associated venting systems (*i.e.,* trial standard levels (''TSLs'') 2, 3, and 4) in its analysis of potential energy conservation standards. Any adverse impacts on utility and availability of non-condensing technology options are considered in DOE's analyses of these TSLs.

As illustrated by the preceding discussion, the rulemaking for CWH equipment has been subject to multiple rounds of public comment, including public meetings, and extensive records have been developed in the relevant dockets. (See Docket Number EERE–2014–BT–STD–0042, respectively). Consequently, the information obtained through those earlier rounds of public comment, information exchange, and data gathering have been considered in this rulemaking and DOE is building upon the existing record through further analysis and further notice and comment.

C. Deviation From Appendix A

On January 11, 2022, DOE published a test procedure NOPR for consumer water heaters and residential-duty commercial water heaters. 87 FR 1554. In accordance with section 3(a) of 10 CFR part 430, subpart C, appendix A (''appendix A''), DOE notes that it is deviating from the provision in appendix A specifying that test procedures be finalized at least 180 days before new or amended standards are proposed for the same equipment. 10 CFR part 430, subpart C, appendix A, section 8(d)(2). DOE is opting to deviate from this step because the proposed test procedure amendments for residential-duty commercial water heaters are not expected to impact the current efficiency ratings. Further, the test procedure final rule for consumer water heaters and residential-duty commercial water heaters is expected to publish before a final rule in this proposed rulemaking. If DOE determines that the test procedure amendments for residential-duty commercial water heaters do in fact impact the efficiency ratings, DOE will review the implications of those changes before finalizing amended standards for residential-duty commercial water heaters.

Issue 1: DOE requests comment on its assumption that the proposed test procedure amendments for residential-duty commercial water heaters are not expected to impact the efficiency ratings.

III. General Discussion

DOE developed this proposed rule after considering comments, data, and information from interested parties that represent a variety of interests. This proposed rule addresses issues raised by commenters to the extent relevant to the preparation of this NOPR.

A. Test Procedures

DOE's current test procedures for CWH equipment are specified at 10 CFR 431.106 and provide mandatory methods for determining the thermal efficiency, standby loss, and UEF, as applicable, of CWH equipment.

As noted previously, on October 21, 2004, DOE published the October 2004 direct final rule, which adopted amended test procedures for CWH equipment. 69 FR 61974. These test procedure amendments incorporated by reference certain sections of ANSI Z21.10.3–1998, ''Gas Water Heaters, Volume III, Storage Water Heaters with Input Ratings above 75,000 Btu per Hour, Circulating and Instantaneous.'' *Id.* at 69 FR 61983. On May 16, 2012, DOE published a final rule for certain commercial heating, air-conditioning, and water heating equipment in the **Federal Register** that, among other things, updated the test procedures for certain CWH equipment by incorporating by reference ANSI Z21.10.3–2011. 77 FR 28928. These updates did not materially alter DOE's test procedure for CWH equipment.

On May 9, 2016, DOE published a NOPR that proposed to amend the test procedures for certain CWH equipment (''May 2016 CWH TP NOPR''). 81 FR 28588. In the May 2016 CWH TP NOPR, DOE proposed several changes, including (1) updating references of industry test standards to incorporate by reference the most recent versions of the industry standards; (2) updating the requirements for ambient conditions, measurement locations, and measurement intervals for the thermal efficiency and standby loss test procedures; (3) amending the test procedure set-up requirements for storage water heaters, storage-type instantaneous water heaters, instantaneous water heaters, and hot water supply boilers; (4) developing a test method for determining the standby loss of unfired hot water storage tanks; (5) updating provisions for setting the tank thermostat for storage and storage-type instantaneous water heaters prior to the thermal efficiency and standby loss tests; (6) clarifying the thermal efficiency and standby loss test procedures with regard to stored energy loss and manipulation of settings during efficiency testing; (7) defining ''storage-type instantaneous water heater'' and modifying several definitions for certain consumer water heaters and CWH equipment included at 10 CFR 430.2 and 10 CFR 431.102, respectively; (8) updating DOE's procedures for determining storage volume and standby loss of instantaneous water heaters and hot water supply boilers (other than storage-type instantaneous water heaters); (9) developing a new test procedure for commercial heat pump water heaters and incorporating by reference certain sections, figures, and tables from ASHRAE 118.1–2012; (10) establishing a procedure for determining the fuel input rate of gas-fired and oil-fired CWH equipment and clarifying DOE's certification and enforcement regulations regarding fuel input rate; and (11) establishing default values for certain testing parameters for oil-fired CWH equipment.

On November 10, 2016, DOE published a final rule amending the test procedures for certain CWH equipment (''November 2016 CWH TP final rule''). 81 FR 79261. In the November 2016 CWH TP final rule, DOE generally adopted the proposals set forth in the May 2016 CWH TP NOPR, except that it did not adopt the following proposals: (1) Ambient humidity requirements, (2) tightened ambient room temperature allowable range (75 °F ± 5 °F), and (3) requirements that the certified fuel input rate be equal to the mean of the measured values of fuel input rate in a sample. In that final rule, DOE also amended its regulations for gas supply and outlet pressure of gas-fired CWH equipment, modified the definition for ''storage-type instantaneous water heater,'' and updated the requirements for establishing steady-state operation. DOE received many industry comments in response to DOE's proposed standby loss test procedure for unfired hot water storage tanks, and in the November 2016 CWH TP final rule, DOE stated that it was still considering these comments and would address the comments and its proposed test procedure for unfired hot water storage tanks in a separate rulemaking notice. 81 FR 79261, 79277 (Nov. 10, 2016).

In addition, as discussed in section II.B, AEMTCA amended EPCA to require that DOE publish a final rule establishing a uniform efficiency descriptor and accompanying test methods for covered consumer water heaters and certain CWH equipment. (42 U.S.C. 6295(e)(5)(B)) The AEMTCA amendments required DOE, in the final rule, to replace the current energy factor (for consumer water heaters) and thermal efficiency and standby loss (for commercial water heaters) metrics with a uniform efficiency descriptor. (42 U.S.C. 6295(e)(5)(C)) However, under the AEMTCA amendments, DOE may provide an exclusion from the uniform efficiency descriptor for specific categories of covered water heaters that do not have residential uses, that can be clearly described, and that are effectively rated using the current thermal efficiency and standby loss descriptors. (42 U.S.C. 6295(e)(5)(F))

The AEMTCA amendments to EPCA further require that, along with developing a uniform descriptor, DOE develop a mathematical conversion factor to translate the results based upon use of the efficiency metric under the test procedure in effect on December 18, 2012, to the new energy descriptor. (42 U.S.C. 6295(e)(5)(E)(i)) In addition, pursuant to 42 U.S.C. 6295(e)(5)(E)(ii) and (iii), the conversion factor must not affect the minimum efficiency requirements for covered water heaters, including residential-duty commercial water heaters. Furthermore, such conversions must not lead to a change in measured energy efficiency for covered residential and residential-duty commercial water heaters manufactured and tested prior to the final rule establishing the uniform efficiency descriptor. *Id.*

In the July 2014 test procedure final rule, DOE, among other things, established the UEF metric, a revised version of the current residential energy factor metric, as the uniform efficiency descriptor required by AEMTCA. 79 FR 40542, 40578–40579 (July 11, 2014).

The uniform efficiency descriptor established in the July 2014 final rule applies to all commercial water heaters that meet the definition of ''residential-duty commercial water heater.'' This term was initially defined in the July 2014 final rule, and later revised in the November 2016 CWH TP final rule. 81 FR 79261, 79288–79289 (Nov. 10, 2016). Residential-duty commercial water heater is defined in 10 CFR 431.102 as any gas-fired storage, oil-fired storage, or electric instantaneous commercial water heater that meets the following conditions:

(1) For models requiring electricity, uses single-phase external power supply;

(2) Is not designed to provide outlet hot water at temperatures greater than 180 °F; and

(3) Does not meet any of the criteria shown in Table III.1, which reflects the table in 10 CFR 431.102.

TABLE III.1—RATED INPUT AND STORAGE VOLUME RANGES FOR NON-RESIDENTIAL-DUTY COMMERCIAL WATER HEATERS

Water heater type	Indicator of non-residential application
Gas-fired storage.	Rated input >105 kBtu/h; Rated storage volume >120 gallons.
Oil-fired storage.	Rated input >140 kBtu/h; Rated storage volume >120 gallons.
Electric instantaneous.	Rated input >58.6 kW; Rated storage volume >2 gallons.

CWH equipment not meeting the definition of ''residential-duty commercial water heater'' was deemed to be sufficiently characterized by the current thermal efficiency and standby loss metrics. DOE provided a method for converting existing thermal efficiency and/or standby loss ratings for residential-duty commercial water heaters to UEF in the December 2016 conversion factor final rule. DOE also adopted UEF standard levels for the equipment, and DOE's methodology for translating the standards ensured equivalent stringency between the then-existing standards (in terms of thermal efficiency and standby loss metrics) and the converted standards (in terms of UEF). 81 FR 96204, 96219–96223 (Dec. 29, 2016).

Compliance with the UEF metric has been mandatory since December 29, 2016, and manufacturers have been required to determine UEF based on UEF test data, rather than using equations to convert from thermal efficiency and standby loss, since December 29, 2017. Therefore, in this NOPR, DOE analyzes residential-duty gas-fired storage water heaters in terms of UEF and does not utilize any UEF conversion factors.

B. Scope of Rulemaking

1. Residential-Duty Commercial Water Heaters

As discussed in the July 2014 final rule, DOE regulates residential-duty commercial water heaters as commercial water heaters. 79 FR 40542, 40544 (July 11, 2014) However, as discussed in section III.B.2 of this document, DOE is not considering amended standards for residential-duty oil-fired storage water heaters because DOE has initially found that the market for this equipment has not changed appreciably since standards were last amended. However, the same is not true for residential-duty gas-fired storage water heaters. DOE has tentatively determined that the market for residential-duty gas-fired storage water heaters has appreciably changed since the July 2014 final rule. DOE is considering amended energy conservation standards for residential-duty commercial gas-fired storage water heaters in the current rulemaking, which addresses commercial water heaters generally.

As discussed in sections II.B and III.A of this document, DOE established that residential-duty commercial water heaters are covered by the new UEF metric in the July 2014 final rule. 79 FR 40542, 40586 (July 11, 2014). The analyses of residential-duty equipment for the withdrawn May 2016 CWH ECS NOPR were conducted in terms of the thermal efficiency and standby loss metrics because there were insufficient efficiency data in terms of UEF available when DOE undertook the analyses for the withdrawn May 2016 CWH ECS NOPR. 81 FR 34440, 34453. Those results were subsequently converted to the UEF metric in the December 2016 NODA. 81 FR 94234. However, data in terms of UEF have since become available; therefore, DOE updated the analysis of residential-duty equipment to be in terms of UEF for this NOPR. Details about the UEF levels analyzed in this NOPR are discussed in sections IV.C.4.c and IV.C.6 of this document.

2. Oil-Fired Commercial Water Heating Equipment

ASHRAE Standard 90.1–2013 raised the thermal efficiency level for commercial oil-fired storage water heaters from 78 percent to 80 percent. In the July 2015 ASHRAE equipment final rule, DOE adopted the ASHRAE Standard 90.1 efficiency level of 80 percent having determined that there was insufficient potential for energy savings to justify further increasing the standard. 80 FR 42614 (July 17, 2015). This standard applied to both residential-duty commercial oil storage water heaters as well as non-residential-duty commercial oil storage water heaters at the time, although equivalent standards in terms of UEF were developed and adopted for residential-duty commercial gas storage water heaters in the December 2016 Conversion Factor Final Rule. 81 FR 96204 (Dec. 29, 2016).

In considering amended efficiency standards for commercial oil-fired storage water heaters (including residential-duty oil-fired storage water heaters) in the withdrawn May 2016 CWH ECS NOPR, DOE initially determined that circumstances did not change appreciably between the publication of the July 2015 ASHRAE equipment final rule and the May 2016 CWH ECS NOPR, and, therefore, DOE did not analyze amended efficiency standards for this equipment in the May 2016 CWH ECS NOPR. 81 FR 34440, 34453. DOE has not received any new or additional information on this issue to suggest that DOE should consider amended standards for commercial oil-fired storage water heaters or residential-duty oil-fired storage water heaters and therefore DOE maintains the approach from the withdrawn May 2016 CWH ECS NOPR.

For this NOPR, DOE considered whether amended standby loss standards for commercial oil-fired water heaters would be warranted. DOE has initially determined that a change in the maximum standby loss level would likely effect less of a change in energy consumption of oil-fired storage water heaters than would a change in the thermal efficiency due to the magnitude of energy consumed in active mode as compared to standby losses. Therefore, DOE has tentatively determined that an amended standby loss standard would likely result in only a negligible amount of additional energy savings. Thus, DOE has not analyzed amended standby loss standards for commercial oil-fired storage water heaters in this rulemaking.

DOE also considered oil-fired instantaneous water heaters and hot water supply boilers and only identified a small number of oil-fired tank-type instantaneous units currently on the market that would meet DOE's definition of oil-fired tank-type instantaneous commercial water heaters. DOE estimates that there are very few annual shipments for this equipment class. Therefore, DOE has initially determined that the energy savings possible from amended standards for such equipment is negligible, and thus, would not impact the results of the analyses conducted for this NOPR. Therefore, DOE did not analyze amended standards for commercial oil-fired instantaneous water heaters and hot water supply boilers for this NOPR.

Based on the discussion in the preceding paragraphs, and because DOE has not received new information to contradict its previous findings, DOE tentatively concludes that the potential energy savings resulting from amended standards for commercial oil-fired water heating equipment would be negligible. Any such energy savings from amended standards for commercial oil-fired water heating equipment would not appreciably change the absolute energy savings estimated for CWH equipment; *i.e.,* would not impact the determination of whether amended energy conservation standards for CWH equipment would result in significant energy savings. Thus, DOE has continued to exclude commercial oil-fired water heating equipment from the analysis conducted for this NOPR.

3. Unfired Hot Water Storage Tanks

Unfired hot water storage tanks are a class of CWH equipment. On August 9, 2019, DOE published an RFI initiating an effort to determine whether to amend the current uniform national standard for unfired hot water storage tanks. 84 FR 39220. Subsequently, on June 10, 2021 DOE published a notice of proposed determination and request for comment proposing not to amend energy conservation standards for unfired hot water storage tanks. 86 FR 30796. Because amended energy conservation standards for unfired hot water storage tanks are being considered as part of that proceeding, they were not considered further for this NOPR.

4. Electric Instantaneous Water Heaters

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

DOE is also proposing to allow use of a calculation-based method for determining storage volume of electric instantaneous water heaters that is the same as the method for gas-fired and oil-fired instantaneous water heaters and hot water supply boilers found at 10 CFR 429.72(e) (added at 81 FR 79261, 79320 (Nov. 10, 2016)). DOE has initially concluded that the same rationale for including these provisions for gas-fired and oil-fired instantaneous water heaters and hot water supply boilers also applies to electric instantaneous water heaters (*i.e.,* it may be difficult to completely empty the instantaneous water heater in order to obtain a dry weight measurement, which is needed in a weight-based test for an accurate representation of the storage volume). Therefore, DOE is proposing to include electric instantaneous water heaters in these provisions in order to provide manufacturers with flexibility as to how the storage volume is determined.

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

5. Commercial Heat Pump Water Heaters

In the withdrawn May 2016 CWH ECS NOPR, DOE did not consider energy conservation standards for commercial heat pump water heaters because DOE's proposed test procedure for commercial heat pump water heaters was not finalized, and there were insufficient data with the proposed test procedure for units currently on the market. DOE expressed its intent to consider energy conservation standards for commercial heat pump water heaters in a future rulemaking. 81 FR 34440, 34454–34455 (May 31, 2016). Further, DOE noted that all commercial heat pump water heaters it had identified on the market were ''add-on'' heat pumps designed to be paired with a storage tank in the field, and DOE had not identified any commercial water heater models that integrate a storage tank and heat pump. DOE did not consider commercial integrated heat pump water heaters as a design option for electric storage water heaters because DOE did not identify any such units on the market. 81 FR 34440, 34454 and 34469.

In the November 2016 CWH TP final rule, DOE adopted a test procedure for commercial heat pump water heaters. 81 FR 79261, 79301–79304. However, DOE has initially concluded that there are still limited data using this test procedure for units currently on the market due to limited units on the market. Since the November 2016 CWH TP DOE is aware of only one commercial integrated heat pump water heater model currently on the market. Therefore, DOE did not consider energy conservation standards for commercial heat pump water heaters in this NOPR. As stated in the withdrawn May 2016 CWH ECS NOPR, DOE plans to analyze standards for commercial heat pump water heaters in a future rulemaking, at which time DOE will consider the appropriate equipment class structure for commercial electric water heaters, including commercial heat pump water heaters. Section IV.A.2.f of this NOPR includes discussion of DOE's consideration of grid-enabled water heaters.

6. Electric Storage Water Heaters

In this rulemaking, DOE is not analyzing thermal efficiency standards for electric storage water heaters. Electric storage water heaters are not currently subject to a thermal efficiency standard under 10 CFR 431.110. Electric storage water heaters typically use electric resistance heating elements, which are highly efficient. The thermal efficiency of these units already approaches 100 percent. DOE did not consider commercial integrated heat pump water heaters as the maximum technologically feasible (''max-tech'') for electric storage water heaters at this time. DOE found only one such model on the market, at a single storage volume and heating capacity. Given the wide range of capacities and stored water volumes in products currently on the market, which are required to meet hot water loads in commercial buildings, it is unclear based on this single model whether heat pump water heater technology would be suitable to meet the range of load demands on the market.

Issue 2: DOE requests comment and information on whether integrated heat pump water heaters are capable of meeting the same hot water loads as commercial electric storage water heaters that use electric resistance elements.

Although DOE did not consider an integrated heat pump water heater as a design option for electric storage water heaters, DOE proposed amended standby loss standards for electric storage water heaters in the withdrawn May 2016 CWH ECS NOPR based on increased insulation thickness. 81 FR 34440, 34443 (May 31, 2016). In response to the withdrawn May 2016 CWH ECS NOPR, DOE received several comments opposing the proposed amended standby loss standard for electric storage water heaters. Summaries of these comments and DOE's responses are included in section IV.C.4.b of this NOPR. After consideration of industry comments and closer examination of the market, DOE recognizes that the only technology option that DOE analyzed in the engineering analysis as providing standby loss reduction for electric storage water heaters (*i.e.,* increasing tank foam insulation thickness to 3 inches) is already currently included in some models rated at or near the current standby loss standard. Consequently, DOE did not analyze any technology options for reducing standby loss below (*i.e.,* more stringent than) the current standard, and therefore, this NOPR does not propose to amend the standby loss standard for electric storage water heaters. Section IV.C.4.b of this NOPR includes further discussion of standby loss levels for electric storage water heaters and DOE's decision not to amend standby loss standards for electric storage water heaters.

7. Instantaneous Water Heaters and Hot Water Supply Boilers

Other than storage-type instantaneous water heaters, DOE did not include instantaneous water heaters and hot water supply boilers in its analysis of potential amended standby loss standards.[16] Instantaneous water heaters and hot water supply boilers (other than storage-type instantaneous water heaters) with greater than 10 gallons of water stored have a standby loss requirement under 10 CFR 431.110. However, DOE did not analyze more stringent standby loss standards for these units because it has initially determined that such amended standards would result in minimal energy savings. DOE identified only 81 out of 468 models on the market of instantaneous water heaters or hot water supply boilers with greater than or equal to 10 gallons of water stored (other than storage-type instantaneous water heaters), and 32 of the identified models have less than 15 gallons of water stored. Even if DOE were to account for the energy savings potential of amended standby loss standards for instantaneous water heaters and hot water supply boilers (other than storage-type instantaneous water heaters) with greater than 10 gallons of water stored CWH equipment, the contribution of any potential energy savings from amended standards for these units would be negligible and not appreciably impact the energy savings analysis for CWH equipment.

DOE has initially determined that instantaneous water heaters (other than storage-type instantaneous water heaters) and hot water supply boilers with less than 10 gallons of water stored would not have significantly different costs and benefits as compared to instantaneous water heaters (other than storage-type instantaneous water heaters) and hot water supply boilers with greater than or equal to 10 gallons of water stored. Therefore, DOE analyzed both equipment classes of instantaneous water heaters and hot water supply boilers (less than 10 gallons and greater than or equal to 10 gallons stored volume) together for thermal efficiency standard levels in this NOPR.

DOE also initially determined that establishing standby loss standards for instantaneous water heaters and hot water supply boilers with less than or equal to 10 gallons water stored would result in minimal energy savings. Even if DOE were to account for the energy savings potential of amended standby loss standards for instantaneous water

[16] DOE adopted a definition for ''storage-type instantaneous water heater'' in the November 2016 CWH TP final rule. 81 FR 79261, 79289–79290 (Nov. 10, 2016). Storage-type instantaneous water heaters are discussed in section IV.A.2.b of this NOPR.

heaters and hot waters supply boilers with less than or equal to 10 gallons of water stored, the contribution any potential energy savings from amended standards for these units would be negligible and not appreciably impact the energy savings analysis for CWH equipment. For instantaneous water heaters and hot water supply boilers (other than storage-type instantaneous water heaters), DOE has not found and did not receive any information or data suggesting that DOE should analyze amended standby loss standards or separately analyze amended thermal efficiency standards for each stored volume range (less than 10 gallons, and greater than or equal to 10 gallons stored volume).

C. 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 is 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 these means for improving efficiency are technologically feasible. DOE considers technologies incorporated in commercially-available equipment or in working prototypes to be technologically feasible.

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; and (3) adverse impacts on health or safety. *See generally* 10 CFR 431.4; 10 CFR part 430, subpart C, appendix A, sections 6(c)(3)(ii)–(v) and 7(b)(2)–(5). Additionally, it is DOE's policy not to include in its analyses any proprietary technology that is a unique pathway to achieving a certain efficiency level. Section IV.B of this document discusses the results of the screening analysis for CWH equipment, particularly the designs DOE considered, those it screened out, and those that are the basis for the standard levels considered in this proposed rulemaking. For further details on the screening analysis for this proposed 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 equipment, it determines the maximum improvement in energy efficiency or maximum reduction in energy use that is technologically feasible for such equipment. Accordingly, in the engineering analysis, DOE determined the max-tech improvements in energy efficiency for CWH equipment, using the design parameters for the most efficient products available on the market. The max-tech levels that DOE determined for this proposed rulemaking are described in section IV.C.4 of this NOPR and chapter 5 of the NOPR TSD.

D. Energy Savings

1. Determination of Savings

For each TSL, DOE projected energy savings from the application of the TSL to CWH equipment purchased in the 30-year period that begins in the first full year of compliance with potential standards (2026–2055 for gas-fired CWH equipment).[17] The savings are measured over the entire lifetime of CWH equipment 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 amended energy conservation standards.

DOE used its national impacts analysis (''NIA'') spreadsheet model to estimate national energy savings (''NES'') from potential amended standards for CWH equipment. The NIA spreadsheet model (described in section IV.H of this document) calculates energy savings in terms of site energy, which is the energy directly consumed by equipment at the locations where they are used. For electricity, DOE reports NES in terms of primary energy savings, which is the savings in the energy that is used to generate and transmit the site electricity. For natural gas, the primary energy savings are considered to be equal to the site energy savings because they are supplied to the user without transformation from another form of energy.

DOE also calculates NES in terms of full-fuel cycle (''FFC'') energy savings. The FFC metric includes the energy consumed in extracting, processing, and transporting primary fuels (*e.g.,* coal, natural gas, petroleum fuels), and thus presents a more complete picture of the impacts of energy conservation standards.[18] DOE's approach is based on the calculation of an FFC multiplier for each of the energy types used by covered equipment.[19] For more information on FFC energy savings, see section IV.H.3 of this document.

2. Significance of Savings

To adopt any new or amended standards for covered equipment, DOE must determine that such action would result in significant energy savings. (See 42 U.S.C. 6313(a)(6)(C)(i); 42 U.S.C. 6313(a)(6)(A)(ii)(II)) [20]

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.[21] For example, the United States has now rejoined the Paris Agreement and will exert leadership in confronting the climate crisis.[22] Additionally, 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. In evaluating the significance of energy savings, DOE considers differences in primary energy and FFC effects for different covered products and equipment when determining whether energy savings are significant.

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

[18] The FFC metric is discussed in DOE's statement of policy and notice of policy amendment. 76 FR 51282 (Aug. 18, 2011), as amended at 77 FR 49701 (Aug. 17, 2012).

[19] Natural gas and electricity were the energy types analyzed in the FFC calculations.

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

[21] The numeric threshold for determining the significance of energy savings established in a final rule published on February 14, 2020 (85 FR 8626, 8670), was subsequently eliminated in a final rule published on December 13, 2021 (86 FR 70755).

[22] See Executive Order 14008, 86 FR 7619 (Feb. 1, 2021) (''Tackling the Climate Crisis at Home and Abroad'').

Primary energy and FFC effects include the energy consumed in electricity production (depending on load shape), in distribution and transmission, and in extracting, processing, and transporting primary fuels (*i.e.,* coal, natural gas, petroleum fuels), and thus present a more complete picture of the impacts of energy conservation standards.

Accordingly, DOE evaluates the significance of energy savings on a case-by-case basis, taking into account the significance of cumulative FFC national energy savings, the cumulative FFC emissions reductions, and the need to confront the global climate crisis, among other factors. As stated, the proposed standards would result in estimated national energy savings of 0.70 quad, the equivalent of the electricity use of 7.0 million homes in one year. DOE has initially determined, based on the methodology described in section IV.E and the analytical results presented in section V.B.3.a, that there is clear and convincing evidence that the energy savings for the TSL proposed in this rulemaking are ''significant'' within the meaning of 42 U.S.C. 6313(a)(6)(A)(ii)(II).

E. Economic Justification

1. Specific Criteria

EPCA provides seven factors to be evaluated in determining whether a potential energy conservation standard for CWH equipment is economically justified. (42 U.S.C. 6313(a)(6)(B)(ii)(I)–(VII) and (C)(i)) The following sections discuss how DOE has addressed each of those seven factors in this rulemaking.

a. Economic Impact on Manufacturers and Commercial Consumers

EPCA requires DOE to consider the economic impact of a standard on manufacturers and the commercial consumers of the products subject to the standard. (42 U.S.C. 6313(a)(6)(B)(I) and (C)(i)) In determining the impacts of a potential amended standard on manufacturers, DOE typically conducts an MIA. For the MIA, DOE first uses an annual cash-flow approach to determine the quantitative impacts. This step incorporates both a short-term impact 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 impact assessment (over a 30-year period).[23] The industry-wide impacts analyzed include: (1) INPV, which values the industry on the basis of expected future cash flows; (2) cash flows by year; (3) changes in revenue and income; and (4) other measures of impact, as appropriate. Second, DOE analyzes and reports the impacts on different types of manufacturers (manufacturer subgroups), including impacts on small manufacturers. Third, DOE considers the impact of standards on domestic manufacturer employment and manufacturing capacity, as well as the potential for new and amended 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 commercial 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 commercial consumers in the aggregate, DOE also calculates the national net present value of the economic impacts applicable to a particular rulemaking. DOE also evaluates the LCC impacts of potential standards on identifiable subgroups of commercial consumers that may be affected disproportionately by a national standard.

b. Savings in Operating Costs Compared to Increase in Price (Life-Cycle Costs)

EPCA requires DOE to consider the savings in operating costs throughout the estimated average life of CWH equipment compared to any increase in the price of the equipment that is likely to result from the standard. (42 U.S.C. 6313(a)(6)(B)(ii)(II); 42 U.S.C. 6313(a)(6)(C)(i)) DOE conducts this comparison in its LCC and PBP analysis.

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

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

The LCC savings are calculated relative to a no-new-standards case that reflects projected market trends in the absence of amended standards. DOE identifies the percentage of commercial consumers estimated to receive LCC savings or experience an LCC increase, in addition to the average LCC savings associated with a particular standard level. DOE's LCC analysis is discussed in further detail in section IV.F of this NOPR.

c. Energy Savings

Although significant conservation of energy is a separate statutory requirement for adopting an energy conservation standard, EPCA requires DOE, in determining the economic justification of a standard, to consider the total projected energy savings that are expected to result directly from the standard. (42 U.S.C. 6313(a)(6)(B)(ii)(III)) As discussed in section IV.H of this NOPR and chapter 10 of the NOPR TSD, DOE uses the NIA spreadsheet to project NES.

d. Lessening of Utility or Performance of Products

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

Although the standards proposed in this NOPR would, if adopted, effectively eliminate non-condensing technology (and associated venting), DOE has recently published a final interpretive rule that returns to the previous and long-standing interpretation (in effect prior to the January 15, 2021 final interpretive rule), under which the technology used to supply heated air or hot water is not a performance-related ''feature'' that provides a distinct utility under EPCA. 86 FR 73947 (Dec. 29, 2021). Therefore, for the purpose of the analysis conducted for this rulemaking DOE is not precluded from setting

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

energy conservation standards that preclude non-condensing technology and did not analyze separate equipment classes for non-condensing and condensing CWH equipment in this NOPR.

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. (*See* 42 U.S.C. 6313(a)(6)(B)(ii)(V)) DOE will transmit a copy of this proposed rule to the Attorney General with a request that the 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 conservation in determining whether a new or amended standard is economically justified. (42 U.S.C. 6313(a)(6)(B)(ii)(VI)) The energy savings from the proposed standards are likely to provide improvements to the security and reliability of the Nation's energy 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. As part of the analysis of the need for national energy and water conservation, DOE conducts an emissions analysis to estimate how potential standards may affect these emissions, as discussed in section IV.K of this document; the estimated emissions impacts are reported in section V.B.6 of this document.[24] DOE also estimates the economic value of emissions reductions resulting from the considered TSLs, as discussed in section IV.L of this document. DOE emphasizes that the SC–GHG analysis presented in this NOPR and TSD was performed in support of the cost-benefit analyses required by Executive Order 12866, and is provided to inform the public of the impacts of emissions reductions resulting from this proposed rule. The SC–GHG estimates were not factored into DOE's EPCA analysis of the need for national energy and water conservation.

g. Other Factors

EPCA allows the Secretary of Energy, in determining whether a standard is economically justified, to consider any other factors that the Secretary deems to be relevant. (42 U.S.C. 6313(a)(6)(B)(ii)(VII) and (C)(i)) DOE did not consider other factors for this document.

2. Rebuttable Presumption

EPCA creates a rebuttable presumption that an energy conservation standard is economically justified if the additional cost to the consumer of a product that meets the standard is less than three times the value of the first year's energy savings resulting from the standard, as calculated under the applicable DOE test procedure. DOE's LCC and PBP analyses generate values used to calculate the effects that potential amended energy conservation standards would have on the PBP for commercial consumers. These analyses include, but are not limited to, the 3-year PBP contemplated under the rebuttable-presumption test.

In addition, DOE routinely conducts an economic analysis that considers the full range of impacts to commercial consumers, manufacturers, the Nation, and the environment, as required under 42 U.S.C. 6313(a)(6)(B)(ii) and 42 U.S.C. 6313(a)(6)(C)(i). The results of this analysis serve as the basis for DOE's evaluation of the economic justification for a potential standard level (thereby supporting or rebutting the results of any preliminary determination of economic justification). The rebuttable presumption payback calculation is discussed in section V.B.1.c of this document.

F. Revisions to Notes in Regulatory Text

In the withdrawn May 2016 CWH ECS NOPR, DOE proposed to modify the three notes to the table of energy conservation standards in 10 CFR 431.110. 81 FR 34440, 34458 (May 31, 2016). First, DOE proposed to modify the note to the table of energy conservation standards denoted by subscript "a" to maintain consistency with DOE's procedure and enforcement provisions for determining fuel input rate of gas-fired and oil-fired CWH equipment that were proposed in the May 2016 CWH TP NOPR (81 FR 28588, 28622 (May 9, 2016)). Among these changes, DOE proposed that the fuel input rate certified to DOE, which must be equal to the mean of the measured values of fuel input rate in a sample, be used to determine equipment classes and calculate the standby loss standard. Therefore, in the withdrawn May 2016 CWH ECS NOPR, DOE proposed to replace the term "nameplate input rate" with the term "fuel input rate." 81 FR 34440, 34458 (May 31, 2016).

DOE also proposed to remove the note to the table of energy conservation standards denoted by subscript "b." This note clarifies the compliance date for energy conservation standards for hot water supply boilers with capacity less than 10 gallons. Specifically, the note says that the standards in the table are mandatory for such equipment beginning on October 21, 2005, but that between October 23, 2003 and October 21, 2005 manufacturers may either comply with the standards listed in the table for hot water supply boilers with less than 10 gallons of storage or with the standards in subpart E of 10 CFR part 431 for a "commercial packaged boiler." DOE determined that this note is no longer needed because the specific compliance dates for hot water supply boilers with less than 10 gallons of storage is well in the past, with all such equipment being required to meet the standards in the table in 10 CFR 431.110 since October 21, 2005. *Id.*

DOE also proposed to modify the note to the table of energy conservation standards denoted by subscript "c," which establishes design requirements for water heaters and hot water supply boilers having more than 140 gallons of storage capacity that do not meet the standby loss standard. DOE proposed to replace the phrase "fire damper" with the phrase "flue damper," because "flue damper" was more consistent with commonly used terminology and likely the intended meaning, and that "fire

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

damper'' was a typographical error.[25] The intent of this design requirement was to require that any water heaters or hot water supply boilers greater than 140 gallons that do not meet the standby loss standard must have some device that physically restricts heat loss through the flue, either a flue damper or blower that sits atop the flue. *Id.*

In response to the withdrawn May 2016 CWH ECS NOPR, A.O. Smith and Rheem opposed DOE's proposal to replace the term ''nameplate input rate'' with ''fuel input rate.'' A.O. Smith argued that because input rate is one of the characteristics that define a product's DOE classification, a fixed number such as the nameplate rated input is necessary. A.O. Smith stated that manufacturers are required by safety standards to display the rated input on product labels and operating instructions. A.O. Smith also argued that the only role for rated input during efficiency testing is to ensure the unit is firing on rate, and that rated input has no effect on measurement of energy efficiency. A.O. Smith added that replacing the term with ''fuel input rate'' does not help consumers but will add regulatory burden to manufacturers. Rheem disagreed with the method for determining ''fuel input rate'' proposed in the May 2016 CWH TP NOPR and believes that the term ''nameplate input rate'' is clear and consistent for all water heaters and is should remain in subscript ''a.'' Rheem stated that it would only support a change to the term ''fuel input rate'' if the method of determining fuel input rate remains unchanged from how it is currently performed in industry. (A.O. Smith, No. 39 at pp. 6–7; Rheem, No. 43 at p. 8)

In the November 2016 CWH TP final rule, DOE did not adopt its proposed certification provisions for fuel input rate. DOE stated that the safety certification process during the design and development of CWH equipment is sufficient for determining the rated input for CWH equipment. Additionally, DOE adopted the term ''rated input'' to mean the maximum rate at which CWH equipment is rated to use energy as specified on the nameplate and adopted the term ''fuel input rate'' to mean the rate at which any particular unit of CWH equipment consumes energy during testing. 81 FR 79261, 79304–79306 (Nov. 10, 2016). To maintain consistency with the November 2016 CWH TP final rule, DOE is no longer proposing to adopt its proposal in the May 2016 CWH ECS NOPR to replace the term ''nameplate input rate'' with the term ''fuel input rate.'' Instead, DOE is proposing to replace the term ''nameplate input rate'' with the term ''rated input.'' DOE notes that this change simply ensures consistency in nomenclature throughout DOE's regulations for CWH equipment. Similar to the term ''nameplate input rate,'' the term ''rated input'' also refers to the input rate specified on the nameplate of CWH equipment. Additionally, in this NOPR, DOE continues to propose the other revisions initially proposed in the May 2016 CWH ECS NOPR to subscript ''b'' and ''c'' of 10 CFR 431.110 for the reasons previously stated.

Issue 3: DOE requests comment on its proposed revisions to notes to the table of energy conservation standards in 10 CFR 431.110.

G. Certification, Compliance, and Enforcement Issues

In the withdrawn May 2016 CWH ECS NOPR, DOE proposed to add requirements to its certification, compliance, and enforcement regulations at 10 CFR 429.44 that the rated value of storage volume must equal the mean of the measured storage volume of the units in the sample. 81 FR 34440, 34458 (May 31, 2016). DOE notes that there are currently no requirements from the Department limiting the amount of difference that is allowable between the tested (*i.e.,* measured) storage volume and the ''rated'' storage volume that is specified by the manufacturer for CWH equipment other than residential-duty commercial water heaters. In the July 2014 test procedure final rule, DOE established a requirement for consumer water heaters and residential-duty commercial water heaters that requires the rated volume to be equal to the mean of the measured volumes in a sample. 79 FR 40542, 40565 (July 11, 2014).

From examination of reported measured storage volume data in the AHRI Directory, DOE observed that many units are rated at storage volumes above the measured storage volume. DOE's maximum standby loss equations for gas-fired and oil-fired CWH equipment are based on the rated storage volume, and the maximum standby loss standard increases as rated storage volume increases. Consequently, DOE proposed to require that the rated storage volume must be equal to the mean of the values measured using DOE's test procedure. In addition, DOE proposed to specify that for DOE-initiated testing, the mean of the measured storage volumes must be within 5 percent of the rated volume in order to use the rated storage volume in calculation of maximum standby loss. If the mean of the measured storage volume is more than 5 percent different than the rated storage volume, then DOE proposed to use the mean of the measured values in calculation of maximum standby loss. DOE notes that similar changes were made to DOE's certification, compliance, and enforcement regulations for residential and residential-duty water heaters in the July 2014 final rule. 79 FR 40542, 40565 (July 11, 2014). In the May 2016 CWH ECS NOPR, DOE requested comment on its proposed changes to the certification, compliance, and enforcement regulations requiring the rated volume to be equal to the mean of the measured volumes in a sample.

AHRI, Bock, A.O. Smith, and Bradford White opposed DOE's proposed changes to 10 CFR 429.44(b)(1)(ii)(C), which would make the rated volume equal to the mean of measured storage volumes within the sample. (AHRI, No. 40 at p. 37; Bock, No. 33 at p. 3; A.O. Smith, No. 39 at p. 7; Bradford White, No. 42 at p. 3) AHRI, Bock, A.O. Smith, Bradford White, and Rheem stated that the relationship of measured volume and rated volume is already addressed by the applicable water heater safety standards. (AHRI, No. 40 at p. 37; Bock, No. 33 at p. 3; A.O. Smith, No. 39 at p. 7; Bradford White, No. 42 at p. 3; Rheem, No. 43 at p. 9) Bock stated that safety certification with ANSI Z21.10.3–2015 requires that rated storage volume be within ±5 percent of the measured volume. Therefore, Bock argued that DOE should use rated volume for the calculation of maximum standby loss, and the certifying agency, ANSI, should resolve any discrepancy beyond a threshold of 5 percent between rated and measured volume with the manufacturer. (Bock, No. 33 at p. 3)

AHRI, Rheem, Bradford White, and A.O. Smith commented that DOE's proposed changes regarding certification of rated volume are unnecessary. (AHRI, No. 40 at p. 37; Rheem, No. 43 at p. 9; Bradford White, No. 42 at p. 3; A.O. Smith, No. 39 at p. 7) AHRI commented that there is no evidence that the current practice of determining rated volume has caused any problems in the field or in the compliance of CWH equipment with the existing energy conservation standards. (AHRI, No. 40 at p. 37) AHRI and Rheem suggested that it is also

[25] In the January 2001 final rule, DOE used the terminology ''flue damper'' in the footnote to the standards table. 66 FR 3356. The October 2004 final rule, which recodified the existing standards to be contiguous with newly adopted test procedures, changed the footnote terminology to ''fire damper'' without providing rationale. 69 FR 61985. Further, ASHRAE Standard 90.1 has consistently used the term ''flue damper'' to describe the requirements. Therefore, DOE concluded the change in the October 2004 final rule was likely inadvertent.

outside of DOE's authority to redefine how rated volume is determined because it is not an energy conservation metric. (AHRI, No. 40 at p. 37; Rheem, No. 43 at p. 10) AHRI stated that it filed a petition with DOE which was published in the **Federal Register** on November 7, 2014 (79 FR 66338) in response to a similar provision included in the July 2014 final rule for consumer water heaters and residential-duty commercial water heaters. Specifically, AHRI's petition sought the repeal of provisions that required the rated volume to be equal to the mean of the measured volumes in a sample for consumer water heaters and residential-duty commercial water heaters. AHRI stated in the petition that these amendments in effect increase the stringency of the applicable minimum standards for residential water heaters, are unnecessary to develop a uniform energy descriptor, do not coincide with industry practice, and would impose significant burden on manufacturers in terms of additional testing and rewriting of market literature. (AHRI, No. 40 at p. 37) Rheem added that to define rated storage volume in the manner proposed in the May 2016 CWH ECS NOPR provides no measurable benefits nor addresses any known complaints, and it only would serve to infringe on industry standards and customary practice in the marketplace (*i.e.,* requiring rated volume to be equal to the mean of measured volumes, rather than allowing a 5-percent tolerance when determining rated volume as included in ANSI Z21.10.3–2015). (Rheem, No. 43 at p. 10)

AHRI argued that according to 42 U.S.C. 6314(a)(4)(A), DOE is required to adopt ''generally accepted industry test procedures'' unless that procedure either does not adequately measure energy or is unduly burdensome. AHRI stated that establishing certification and enforcement regulations for the rated volume of storage water heaters is contrary to the policy established by Office of Management and Budget (''OMB'') Circular No. A–119 and Executive Order 13563, in that DOE has provided no evidence or compelling arguments that voluntary consensus standards requirements for rated volume have failed to serve the agency's needs. (AHRI, No. 40 at p. 38)

Rheem stated that while rated storage volume is used as a variable in the standby loss equations for gas-fired and oil-fired CWH equipment, thermal efficiency is the desired energy efficiency value for these classes of CWH equipment in the industry and marketplace. Rheem commented that thermal efficiency is not dependent on storage volume. Conversely, Rheem stated that standby loss is the desired energy efficiency metric for electric storage water heaters, but the current maximum standby loss equation uses measured storage volume and not rated storage volume. Therefore, Rheem argued that rated storage volume is not a critical input to determining the desired energy efficiency values by commercial consumers of CWH equipment. (Rheem, No. 43 at p. 10)

After considering the comments, DOE is not proposing to change the requirements regarding certification of storage volume in this NOPR.

Additionally, in the withdrawn May 2016 CWH ECS NOPR DOE proposed changes to the equations for maximum standby losses that would be consistent with the proposed changes to DOE's certification, compliance, and enforcement regulations. DOE received several comments on these proposals. (A.O. Smith, No. 39 at p. 7; Bradford White, No. 42 at pp. 3–4; AHRI, Public Meeting Transcript, No. 20 at p. 14; Rheem, No. 43 at pp. 10–11) However, because DOE is no longer proposing changes to the storage volume determination of CWH equipment in this NOPR, DOE is also no longer proposing to change the equations to calculate maximum standby losses.

DOE is not proposing to establish equipment-specific certification requirements for electric instantaneous water heaters in this NOPR. DOE may propose to establish certification requirements for electric instantaneous water heaters in future rulemakings.

H. General Comments

As discussed in section II.A of this NOPR, pursuant to EPCA, DOE must determine, supported by clear and convincing evidence, that amended standards for CWH equipment would result in significant additional conservation of energy and be technologically feasible and economically justified. (42 U.S.C. 6313(a)(6)(A)(ii)(II); 42 U.S.C. 6313(a)(6)(C)(i)) The statutory criteria require more than just a consideration of a standard level that provides the maximum improvement in energy savings for CWH equipment. In making the determination of economic justification of an amended standard, DOE must determine whether the benefits of the proposed standard exceed the burdens of the proposed standard by considering, to the maximum extent practicable, the seven criteria described in EPCA (*see* 42 U.S.C. 6313(a)(6)(B)(ii)(I)–(VII)). A discussion of DOE's consideration of the statutory factors is contained in section V of this NOPR.

The clear and convincing threshold is a heightened standard, and would only be met where the Secretary has an abiding conviction, based on available facts, data, and DOE's own analyses, that it is highly probable an amended standard would result in a significant additional amount of energy savings, and is technologically feasible and economically justified. *See American Public Gas Association* v. *U.S. Dep't of Energy,* No. 20–1068, 2022 WL 151923, at *4 (D.C. Cir. January 18, 2022) (citing *Colorado* v. *New Mexico,* 467 U.S. 310, 316, 104 S.Ct. 2433, 81 L.Ed.2d 247 (1984)).

In response to the withdrawn May 2016 CWH ECS NOPR, DOE received comments and information regarding the assumptions that it used for inputs in the rulemaking analyses. DOE considered these comments in appropriate analyses conducted in this NOPR and modified its assumptions and inputs as necessary to account for the information or feedback provided by industry representatives. For example, DOE received comments from stakeholders about the achievable standby loss levels of gas-fired and electric storage water heaters. DOE used the suggestions provided in these comments and updated its analyzed standby loss levels to better reflect models currently on the market and the technology options that are used to reduce standby loss. Based on comments from stakeholders regarding the standby loss of electric storage water heaters, DOE concluded that the only technology option analyzed in the withdrawn NOPR would not reduce standby loss for all models on the market across the range of storage volumes. Therefore, DOE did not analyze amended energy conservation standards for electric storage water heaters for this NOPR.

Several stakeholders commented that DOE's analysis incorrectly estimates the energy use of CWH equipment (AHRI, No. 40 at p. 1; A.O. Smith, No. 39 at p. 3; IECA, No. 24 at p. 1; Spire, No. 45 at pp. 12–13) and costs to commercial consumers (AHRI, No. 40 at p. 1; A.O. Smith, No. 39 at p. 3; IECA, No. 24 at p. 1; Bock, No. 33 at p. 2), and underestimates the market share of higher-efficiency (*i.e.,* condensing) gas-fired CWH equipment currently on the market (AHRI, No. 40 at p. 1; Bock, No. 33 at p. 2). AHRI further argued that DOE's analysis overestimates the future shipments of CWH equipment. (AHRI, No. 40 at p. 1) IECA argued that DOE substantially overstated the potential benefits of the proposed standards and understated the negative impact on U.S. manufacturing jobs. (IECA, No. 24 at p. 1)

In response, DOE notes that for this NOPR, it refined the total shipment estimates and no-new-standards-case efficiency distributions in its analyses by integrating additional shipment data provided by AHRI in response to the withdrawn NOPR. DOE also updated its energy use analysis by incorporating data from CBECS 2012, as suggested by stakeholders.[26] After thoroughly considering the stakeholder's comments regarding installation costs of condensing gas-fired CWH equipment, DOE re-evaluated its installation costs to align more closely with field applications. Furthermore, DOE reiterates that it conducts a rigorous analysis on impacts of amended standards on manufacturers, including impact on direct employment. Section IV of this NOPR provides details on DOE's updates to its various analyses.

Spire argued that significant energy savings cannot be based on the claim that the aggregate additional energy savings for all proposed standards are significant. Spire asserted that DOE's obligation is to consider each standard individually on the basis of clear and convincing evidence. Spire further argued that DOE failed to consider how fuel switching would affect the energy savings and emissions reductions estimated in the withdrawn NOPR. (Spire, No. 45 at p. 5) AGA and APGA recommended that DOE disaggregate the analyses of each equipment class and treat each of its economic justification criteria separately. AGA and APGA further argued that DOE's consideration of each TSL by comparing the commercial consumer LCC results against monetized emission reductions is entirely subjective and leads to uncertainty as to what DOE considers to constitute ''economic justification.'' (AGA and APGA, No. 35 at p. 4)

In response to the comments from Spire and AGA and APGA, as described in section V.A of this NOPR, DOE groups various efficiency levels for each equipment class into TSLs in order to examine the combined impact that amended standards for all analyzed equipment classes would have on an industry. This approach also allows DOE to capture the effects on manufacturers of amended standards for all classes, better reflecting the burdens for manufacturers that produce equipment across several equipment classes. As discussed in section IV.H.2 of this NOPR, DOE also considered the effects of fuel switching by comparing total installed costs and operating costs of competing CWH equipment types. From this analysis, DOE has tentatively concluded that this NOPR will not incentivize fuel switching in the CWH market.

DOE disputes the notion that its consideration of TSLs is subjective. Rather, through a detailed and thorough analysis, DOE considered the benefits and burdens of amended standards for CWH equipment to commercial consumers, the Nation, and manufacturers, in accordance with the criteria described in EPCA (*see* 42 U.S.C. 6313(a)(6)(B)(ii)(I)–(VII)). Contrary to the assertion of AGA and APGA, DOE's economic justification is not based on comparing the commercial consumer LCC results against monetized emissions reductions. In fact, DOE considers a variety of economic factors, including commercial consumer LCC results, NPV of commercial consumer benefits, and manufacturer INPV. DOE presents monetized benefits in accordance with the applicable Executive Orders and DOE would reach the same tentative conclusions presented in this NOPR in the absence of the social cost of greenhouse gases, including the Interim Estimates presented by the Interagency Working Group.

IV. Methodology and Discussion of Related Comments

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

In overview, DOE used several analytical tools to estimate the impact of the standards considered in this document. The first tool is a spreadsheet that calculates the LCC and PBP of potential amended or new energy conservation standards. The NIA uses a second spreadsheet set that provides shipments forecasts and calculates NES and NPV resulting from potential new or amended energy conservation standards.[27] These spreadsheet tools are available on the DOE website for this proposed rulemaking: *www1.eere.energy.gov/buildings/appliance_standards/standards.aspx?productid=36.*

Additionally, DOE estimated the impacts on electricity demand and air emissions from utilities due to the amended energy conservation standards for CWH equipment. DOE used a version of the U.S. Energy Information Administration's (''EIA's'') National Energy Modeling System (''NEMS'') for the electricity and air emissions analyses. The NEMS model simulates the energy sector of the U.S. economy. EIA uses NEMS [28] to prepare its *Annual Energy Outlook* (''*AEO*''), a widely known baseline energy forecast for the United States. The version of NEMS used for appliance standards analysis, which makes minor modifications to the *AEO* version, is called NEMS–BT.[29] NEMS–BT accounts for the interactions among the various energy supply and demand sectors and the economy as a whole.

A. Market and Technology Assessment

For the market and technology assessment for CWH equipment, DOE gathered information that provides an overall picture of the market for the equipment concerned, including the purpose of the equipment, the industry structure, manufacturers, market characteristics, and technologies used in the equipment. This activity included both quantitative and qualitative assessments based primarily on publicly-available information. The subjects addressed in the market and technology assessment for this rulemaking include the following: (1) A determination of equipment classes, (2) manufacturers and industry structure, (3) types and quantities of CWH equipment sold, (4) existing efficiency programs, and (5) technologies that could improve the energy efficiency of CWH equipment. The key findings of DOE's market assessment are summarized below. Chapter 3 of the NOPR TSD provides further discussion of the market and technology assessment.

1. Definitions

EPCA includes the following categories of CWH equipment as

[26] DOE is aware that a new version of CBECS (CBECS 2018) will likely be available for the next rulemaking phase, and DOE will evaluate its applicability for the commercial water heater energy analysis in that phase.

[27] DOE routinely uses a third spreadsheet tool, the Government Regulatory Impact Model (''GRIM''), to assess manufacturer impacts of potential new or amended standards as part of the MIA. However, as discussed in section III.E.1.a of this document, the MIA was not updated for the SNOPR.

[28] For more information on NEMS, refer to EIA. *The National Energy Modeling System: An Overview.* 2018. EIA: Washington, DC. DOE/EIA–0581(2018). Available at *www.eia.gov/outlooks/aeo/.*

[29] EIA approves the use of the name ''NEMS'' to describe only an *AEO* version of the model without any modification to code or data. Because the present analysis entails some minor code modifications and runs the model under various policy scenarios that deviate from *AEO* assumptions, the name ''NEMS–BT'' refers to the model as used here. (BT stands for DOE's Building Technologies Office.)

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

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

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

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

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

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

2. Equipment Classes

When evaluating and establishing energy conservation standards, DOE generally divides covered equipment into equipment classes by the type of energy used or by capacity or other performance-related features that justify a different standard. In determining whether a performance-related feature justifies a different standard, DOE considers such factors as the utility to the commercial consumers of the feature and other factors DOE determines are appropriate.

CWH equipment classes are divided based on the energy source, equipment category (*i.e.,* storage vs. instantaneous and hot water supply boilers), and size (*i.e.,* input capacity and rated storage volume). Unfired hot water storage tanks are also included as a separate equipment class, but as discussed in section III.B.3 of this proposed rulemaking are being considered as part of a separate proceeding and therefore were not analyzed for this NOPR. Table IV.1 shows the current equipment classes and energy conservation standards for CWH equipment other than residential-duty commercial water heaters, and Table IV.2 shows DOE's current equipment classes and energy conservation standards for residential-duty commercial water heaters.

TABLE IV.1—CURRENT EQUIPMENT CLASSES AND ENERGY CONSERVATION STANDARDS FOR CWH EQUIPMENT EXCEPT FOR RESIDENTIAL-DUTY COMMERCIAL WATER HEATERS

Equipment class	Size	Energy conservation standards *	
		Minimum thermal efficiency (equipment manufactured on and after Oct. 9, 2015) ** *** (%)	Maximum standby loss (equipment manufactured on and after Oct. 29, 2003) ** †
Electric storage water heaters	All	N/A	0.30 + 27/V_m (%/h).
Gas-fired storage water heaters	≤155,000 Btu/h	80	Q/800 + 110(V_r)½ (Btu/h).
	>155,000 Btu/h	80	Q/800 + 110(V_r)½ (Btu/h).
Oil-fired storage water heaters	≤155,000 Btu/h	*** 80	Q/800 + 110(V_r)½ (Btu/h).
	>155,000 Btu/h	*** 80	Q/800 + 110(V_r)½ (Btu/h).
Electric instantaneous water heaters ‡	<10 gal	80	N/A.
	≥10 gal	77	2.30 + 67/V_m (%/h).
Gas-fired instantaneous water heaters and hot water supply boilers	<10 gal	80	N/A.
	≥10 gal	80	Q/800 + 110(V_r)½ (Btu/h).
Oil-fired instantaneous water heater and hot water supply boilers	<10 gal	80	N/A
	≥10 gal	78	Q/800 + 110(V_r)½ (Btu/h).
		Minimum thermal insulation	
Unfired hot water storage tank	All	R–12.5	

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

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

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

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

‡ Energy conservation standards for electric instantaneous water heaters are included in EPCA. In this NOPR, DOE codifies these standards for electric instantaneous water heaters in its regulations at 10 CFR 431.110. Further discussion of standards for electric instantaneous water heaters is included in section III.B.4 of this document.

TABLE IV.2—CURRENT EQUIPMENT CLASSES AND ENERGY CONSERVATION STANDARDS FOR RESIDENTIAL-DUTY COMMERCIAL WATER HEATERS

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

* To be classified as a residential-duty water heater, a commercial water heater must, if requiring electricity, use single-phase external power supply, and not be designed to heat water at temperatures greater than 180 °F.

** Draw pattern is a classification of hot water use of a consumer water heater or residential-duty commercial water heater, based upon the first-hour rating. The draw pattern is determined using the *Uniform Test Method for Measuring the Energy Consumption of Water Heaters* in appendix E to subpart B of 10 CFR part 430.

As discussed in section IV.A.2.e, DOE proposed in the May 2016 CWH ECS NOPR to consolidate commercial gas-fired and oil-fired storage water heater equipment classes that are currently divided by input rates of 155,000 Btu/h. 81 FR 34440, 34462 In the May 2016 CWH ECS NOPR, DOE sought comment on the overall proposed equipment class structure for CWH equipment. 81 FR 34440, 34460 (May 31, 2016). The following subsections include clarifications in response to the various comments received.

a. Residential-Duty Electric Instantaneous Water Heaters

Residential-duty electric instantaneous water heaters are a separate equipment class within DOE's regulations for CWH equipment. In the December 2016 conversion factor final rule, DOE established equipment classes and energy conservation standards for residential-duty commercial water heaters, including residential-duty electric instantaneous water heaters. 81 FR 96204, 96239 (Dec. 29, 2016). However, DOE notes that it did not analyze amended energy conservation standards for this equipment class in this NOPR, as further discussed in section III.B.4 of this NOPR.

b. Storage-Type Instantaneous Water Heaters

Based on a review of equipment on the market, DOE has found that gas-fired storage-type instantaneous water heaters are very similar to gas-fired storage water heaters, but with a higher ratio of input rating to tank volume. This higher input-volume ratio is achieved with a relatively larger heat exchanger paired with a relatively smaller tank. Increasing either the input capacity or storage volume increases the hot water delivery capacity of the water heater. However, through a review of product literature, DOE did not identify any significant design differences that would warrant different energy conservation standard levels (for either thermal efficiency or standby loss) between models in these two equipment classes. Therefore, DOE grouped the two equipment classes together in the May 2016 CWH ECS NOPR analyses and proposed the same standard levels for each equipment class.

In the withdrawn May 2016 CWH TP NOPR, DOE noted that the ''gas-fired instantaneous water heaters and hot water supply boilers with a storage volume greater than or equal to 10 gallons'' equipment class encompasses both instantaneous water heaters and hot water supply boilers with large volume heat exchangers, as well as instantaneous water heaters with storage tanks (but with at least 4,000 Btu/h of input per gallon of water stored). 81 FR 28588, 28607 (May 9, 2016). Therefore, in the May 2016 CWH TP NOPR, DOE proposed to define ''storage-type instantaneous water heater'' as an instantaneous water heater that includes a storage tank with a submerged heat exchanger(s) or heating element(s). *Id.* at 81 FR 28637. However, based on industry feedback, in the November 2016 CWH TP final rule, DOE decided not to include the criterion regarding submerged heat exchanger(s) or heating element(s) in the definition. Instead, DOE defined ''storage-type instantaneous water heater'' as an instantaneous water heater that includes a storage tank with a storage volume greater than or equal to 10 gallons. 81 FR 79261, 79289–79290 (Nov. 10, 2016).

In response to the May 2016 CWH ECS NOPR, DOE received various comments regarding the difference (or lack of difference) between storage-type instantaneous water heaters and storage water heaters and questioning whether storage-type instantaneous equipment should be considered in DOE's analysis. (Rheem, No. 43 at p. 11; Bock, No. 33 at p. 3; A.O. Smith, No. 39 at p. 7; Bradford White, No. 42 at p. 4) As stated, the definition for storage-type instantaneous water heaters was finalized in the November 2016 CWH TP final rule. 81 FR 79261, 79289–

79290 (Nov. 10, 2016). For this NOPR DOE has continued to analyze amended energy conservation standards for storage-type instantaneous water heaters in a manner consistent with storage water heaters, as was done in the withdrawn May 2016 CWH ECS NOPR. The potential standard levels considered in this document reflect the similarity of these types of equipment, with the same standard levels considered for both storage water heaters and storage-type instantaneous water heaters.

c. Condensing Gas-Fired Water Heating Equipment

DOE has recently considered whether non-condensing technology (and associated venting) constitutes a performance-related ''feature'' that provides a distinct consumer utility under EPCA which may not be eliminated by an energy conservation standard. On January 15, 2021, in response to a petition for rulemaking submitted by the American Public Gas Association, Spire, Inc., the Natural Gas Supply Association, the American Gas Association, and the National Propane Gas Association (83 FR 54883; Nov. 1, 2018), DOE published the January 2021 final interpretive rule determining that, in the context of residential furnaces, commercial water heaters, and similarly-situated products/equipment, use of non-condensing technology (and associated venting) constitute a performance-related ''feature'' under EPCA that cannot be eliminated through adoption of an energy conservation standard. 86 FR 4776. Correspondingly, DOE withdrew the May 2016 CWH ECS NOPR. 86 FR 3873 (Jan. 15, 2021).

However, DOE has subsequently published a final interpretive rule that returns to the previous and long-standing interpretation (in effect prior to the January 15, 2021 final interpretive rule), under which the technology used to supply heated air or hot water is not a performance-related ''feature'' that provides a distinct consumer utility under EPCA. 86 FR 73947 (Dec. 29, 2021). For the purpose of the analysis conducted for this rulemaking DOE did not analyze separate equipment classes for non-condensing and condensing CWH equipment in this NOPR.

d. Tankless Water Heaters and Hot Water Supply Boilers

In the withdrawn May 2016 CWH ECS NOPR, DOE discussed the differences in design and application between equipment within the ''gas-fired instantaneous water heaters and hot water supply boilers'' equipment class with storage volume less than 10 gallons. 81 FR 34440, 34461–34462 (May 31, 2016). Specifically, DOE identified gas-fired instantaneous water heaters and hot water supply boilers that are ''tankless water heaters'' and those that are ''hot water supply boilers.'' *Id.* From examination of equipment literature and discussion with manufacturers, DOE stated that tankless water heaters are typically used without a storage tank, flow-activated, wall-mounted, and capable of higher temperature rises. Hot water supply boilers, conversely, are typically used with a storage tank and recirculation loop, thermostatically-activated, and not wall-mounted. However, despite these differences, tankless water heaters and hot water supply boilers share basic similarities: Both kinds of equipment supply hot water in commercial applications with at least 4,000 Btu/h per gallon of stored water, and both include heat exchangers through which incoming water flows and is heated by combustion flue gases that flow around the heat exchanger tubes. DOE analyzed tankless water heaters and hot water supply boilers as two separate kinds of representative equipment for the instantaneous water heaters and hot water supply boilers equipment class for the May 2016 CWH ECS NOPR. *Id.*

In response to the May 2016 CWH ECS NOPR, DOE received several comments related to whether tankless water heaters and hot water supply boilers should be treated as separate equipment classes in DOE's energy conservation standards for CWH equipment and whether proposing the same standards incentivizes any switching in shipments from one equipment class to the other. In addition, responses to the withdrawn May 2016 NOPR indicated that some stakeholders were confused by the terminology used in that NOPR and the types of equipment that were considered as representative of this class. (AHRI, No. 40 at pp. 6–8 and Raypak, No. 41 at pp. 6–7; Rheem, No. 43 at p. 12; Bradford White, No. 42 at p. 4)

In the withdrawn May 2016 CWH ECS NOPR analysis, DOE used the term ''hot water supply boiler'' to generally refer not only to hot water supply boilers, but also to instantaneous water heaters that have similar designs and applications as hot waters supply boilers (*i.e.,* instantaneous water heaters other than tankless water heaters and storage-type instantaneous water heaters). DOE recognizes that this terminology may have led to confusion for some stakeholders. Therefore, in this NOPR, DOE refers to this representative equipment within the equipment class of ''gas-fired instantaneous water heaters and hot water supply boilers'' as ''gas-fired circulating water heaters and hot water supply boilers.'' The term ''circulating water heater'' is a commonly used term in industry, and its use is intended to resolve confusion for stakeholders regarding the equipment included in DOE's analyses. DOE is not proposing to define the term ''circulating water heater'' in DOE's regulations, but rather uses the term within this rulemaking notice and the NOPR TSD to clarify the name of representative equipment for the analysis of gas-fired instantaneous water heaters in response to the comments received on the May 2016 CWH ECS NOPR. DOE reiterates that within this NOPR, the term ''circulating water heaters and hot water supply boilers'' refers to both instantaneous water heaters (other than tankless water heaters and storage-type instantaneous water heaters) and hot water supply boilers.

With respect to the issue of whether separate equipment classes are necessary, DOE acknowledges that there are certain design differences between tankless water heaters and circulating water heaters and hot water supply boilers. For this NOPR, DOE maintained its approach of analyzing ''tankless water heaters'' and ''circulating water heaters and hot water supply boilers'' as two separate kinds of representative equipment in the gas-fired instantaneous water heaters equipment class, and presents analytical results separately for the two types of representative equipment in section V of this NOPR, although DOE is not proposing to restructure the equipment classes.

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

In the withdrawn May 2016 CWH ECS NOPR, DOE proposed to consolidate commercial gas-fired and oil-fired storage water heater equipment classes that are currently divided by input rates of 155,000 Btu/h. DOE proposed the following two equipment classes without an input rate distinction: (1) Gas-fired storage water heaters and (2) oil-fired storage water heaters. 81 FR 34440, 34462 (May 31, 2016). The input rate of 155,000 Btu/h was first used as a dividing criterion for storage water heaters in the Energy Policy Act of 1992 (''EPAct 1992'') amendments to EPCA, which mirrored the standard levels and equipment classes in ASHRAE Standard 90.1–1989. (42 U.S.C. 6313(a)(5)(B)–(C)) ASHRAE has since updated its efficiency levels for oil-fired and gas-fired storage water heaters in ASHRAE

Standard 90.1–1999 by consolidating equipment classes that were previously divided by an input rate of 155,000 Btu/h. Pursuant to requirements in EPCA, DOE adopted the increased standards in ASHRAE Standard 90.1–1999, but did not correspondingly consolidate the equipment classes above and below 155,000 Btu/h. As a result, DOE's current standards are identical for the equipment classes that are divided by input rate of 155,000 Btu/h.

For this NOPR, DOE is maintaining its proposal to realign the equipment class structure to eliminate the input rate division at 155,000 Btu/h for commercial gas-fired storage water heaters and oil-fired storage water heaters, consistent with the equipment class structure in the latest version of ASHRAE Standard 90.1.

f. Grid-Enabled Water Heaters

DOE currently only prescribes a standby loss standard for commercial electric storage water heaters, and in this NOPR DOE is not proposing to amend the standby loss level for electric storage water heaters. In the withdrawn May 2016 CWH ECS NOPR DOE had proposed an amended standby loss standard for electric storage water heaters, which DOE determined would be most commonly met by increasing insulation thickness, and which would not differentially affect grid-enabled technology. Therefore, in the May 2016 CWH ECS NOPR, DOE tentatively concluded that a separate equipment class for grid-enabled commercial electric storage water heaters was not warranted. 81 FR 34440 (May 31, 2016). DOE did not receive comments regarding its tentative conclusion in the May 2016 CWH ECS NOPR. Because DOE is not proposing to amend the standard for commercial electric storage water heaters, and because DOE maintains that a grid-enabled water heater would not be differentially impacted by a standby loss standard, DOE is not proposing to establish a separate equipment class for grid-enabled electric storage water heaters in this NOPR.

g. Input Capacity for Instantaneous Water Heaters and Hot Water Supply Boilers

In response to the May 2016 CWH ECS NOPR, DOE received comments suggesting that DOE should split up the equipment class for gas-fired instantaneous water heaters and hot water supply boilers by input capacity, similar to DOE's current energy conservation standards for commercial packaged boilers. (Raypak, No. 41 at p. 7) However, DOE notes that it adopted the current equipment class structure for commercial packaged boilers, including the division by input capacity, from ASHRAE 90.1. As discussed in section IV.A.2.c of this document, EPCA established a specific and separate statutory scheme for establishing and amending energy conservation standards applicable to ASHRAE equipment, including CWH equipment. (*See* 42 U.S.C. 6313(a)(6)) DOE must adopt the level set forth in ASHRAE Standard 90.1 unless the Department has clear and convincing evidence to adopt a more-stringent standard. (*See* 42 U.S.C. 6313(a)(6)). ASHRAE 90.1 does not divide the equipment classes for commercial gas-fired instantaneous water heaters and hot water supply boilers by input capacity. Therefore, DOE has not analyzed separate classes for gas-fired instantaneous water heaters and hot water supply boilers equipment class by input capacity.

3. Review of the Current Market for CWH Equipment

In order to gather information needed for the market assessment for CWH equipment, DOE consulted a variety of sources, including manufacturer literature, manufacturer websites, the AHRI Directory of Certified Product Performance,[30] the CEC Appliance Efficiency Database,[31] and DOE's Compliance Certification Database.[32] DOE used these sources to compile a database of CWH equipment that served as resource material throughout the analyses conducted for this rulemaking. This database contained the following counts of unique models: 768 commercial gas-fired storage water heaters, 94 residential-duty commercial gas-fired storage water heaters, 167 commercial gas-fired storage-type instantaneous water heaters (tank-type water heaters with greater than 4,000 Btu/h per gallon of stored water), 19 gas-fired tankless water heaters, 449 gas-fired circulating water heaters and hot water supply boilers, 115 commercial oil-fired storage water heaters, 2 residential-duty commercial oil-fired storage water heaters, and 36 commercial oil-fired storage-type instantaneous water heaters. No oil-fired tankless water heaters or hot water supply boilers were found on the market. Chapter 3 of the NOPR TSD provides more information on the CWH equipment currently available on the market, including a full breakdown of these units into their equipment classes and graphs showing performance data.

4. Technology Options

As part of the market and technology assessment, DOE uses information about commercially-available technology options and prototype designs to help identify technologies that manufacturers could use to improve energy efficiency for CWH equipment. This effort produces an initial list of all the technologies that are technologically feasible. This assessment provides the technical background and structure on which DOE bases its screening and engineering analyses. Chapter 3 of the NOPR TSD includes descriptions of all technology options identified for this equipment.

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

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

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

[30] Last accessed on March 4, 2021 and available at *www.ahridirectory.org.*

[31] Last accessed on March 4, 2021 and available at *cacertappliances.energy.ca.gov/Pages/ApplianceSearch.aspx.*

[32] Last accessed on February 26, 2021 and available at *www.regulations.doe.gov/certification-data/.*

tank to be included in baseline equipment; therefore, such insulation was not considered as a technology option for the analysis.

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

• Improved insulation (including increasing jacket insulation, insulating tank bottom, advanced insulation types, and foam insulation).
• Mechanical draft (including induced draft (also known as power vent) and forced draft).
• Condensing heat exchanger (for all gas-fired equipment classes and including optimized flue geometry).
• Condensing pulse combustion.
• Improved heat exchanger design (including increased surface area and increased baffling).
• Sidearm heating and two-phase thermosiphon technology.
• Electronic ignition systems.
• Improved heat pump water heaters (including gas absorption heat pump water heaters).
• Premix burner (including submerged combustion chamber for gas-fired storage water heaters and storage-type instantaneous water heaters).
• Electromechanical flue damper.
• Modulating combustion.

B. Screening Analysis

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

• *Technological feasibility.* DOE will consider technologies incorporated in commercial products or in working prototypes to be technologically feasible. Technologies that are not incorporated in commercial equipment or in working prototypes are not considered in this NOPR.

• *Practicability to manufacture, install, and service.* If mass production and reliable installation and servicing of a technology in commercial products could be achieved on the scale necessary to serve the relevant market at the time of the compliance date of the standard, then DOE will consider that technology practicable to manufacture, install, and service.

• *Adverse impacts on product utility or product availability.* If DOE determines a technology would have a significant adverse impact on the utility of the product to significant subgroups of commercial consumers, or would result in the unavailability of any covered product type with performance characteristics (including reliability), features, sizes, capacities, and volumes that are substantially the same as products generally available in the United States at the time, it will not consider this technology further.

• *Adverse impacts on health or safety.* If DOE determines that a technology will have significant adverse impacts on health or safety, it will not consider this technology further.

• *Unique-pathway proprietary technologies.* If a design option utilizes proprietary technology that represents a unique pathway to achieving a given efficiency level, that technology will not be considered further.

10 CFR 431.4; 10 CFR part 430, subpart C, appendix A, sections 6(c)(3) and 7(b).

1. Screened-Out Technologies

Technologies that pass through the screening analysis are subsequently examined in the engineering analysis for consideration in DOE's downstream cost-benefit analysis. Based upon a review under the above factors, DOE screened out the design options listed in Table IV.3 for the reasons provided. Chapter 4 of the NOPR TSD contains additional details on the screening analysis, including a discussion of why each technology option was screened out.

TABLE IV.3—SUMMARY OF SCREENED-OUT TECHNOLOGY OPTIONS

Excluded technology option	Applicable equipment classes *	Reasons for exclusion				
		Technological feasibility	Practicability to manufacture, install, and service	Adverse impacts on product utility	Adverse impacts on health or safety	Unique-pathway proprietary technology
Advanced insulation types	All storage water heaters	X	X			
Condensing pulse combustion.	All gas-fired equipment classes.		X			
Sidearm heating	All gas-fired storage		X			
Two-phase thermosiphon technology.	All gas-fired storage		X			
Gas absorption heat pump water heaters.	Gas-fired instantaneous water heaters.		X			

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

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

2. Remaining Technologies

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

TABLE IV.4—TECHNOLOGY OPTIONS CONSIDERED FOR ENGINEERING ANALYSIS

Equipment	Mechanical draft	Condensing heat exchanger	Increased heat exchanger area, baffling	Electronic ignition	Premix burner	Electro-mechanical flue damper
Commercial gas-fired storage water heaters and storage-type instantaneous water heaters	X	X	X		X	
Residential-duty gas-fired storage water heaters	X	X	X	X	X	X
Gas-fired instantaneous water heaters and hot water supply boilers	X	X	X		X	

C. Engineering Analysis

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

1. Efficiency Analysis

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

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

2. Cost Analysis

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

• *Physical teardowns:* Under this approach, DOE physically dismantles a commercially-available product, component-by-component, to develop a detailed bill of materials (''BOM'') for the product.

• *Catalog teardowns:* In lieu of physically deconstructing a product, DOE identifies each component using parts diagrams (available from manufacturer websites or appliance repair websites, for example) to develop the 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.

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

To account for manufacturers' non-production costs and profit margin, DOE applies a non-production cost multiplier (the manufacturer markup) to the MPC. The resulting manufacturer selling price (''MSP'') is the price at which the manufacturer distributes a unit into commerce. DOE developed an average manufacturer markup by examining the annual Securities and Exchange Commission (SEC) 10–K reports filed by companies that manufacturer CWH equipment. During manufacturer interviews conducted ahead of the May 2016 CWH ECS NOPR, DOE discussed the manufacturer markup and used the industry feedback to modify the manufacturer markup estimate. DOE considers the manufacturer markup published in the May 2016 CWH ECS NOPR to be the best publicly available information.

The approach for this NOPR was similar to that used for the withdrawn May 2016 CWH ECS NOPR, except that the analysis for residential-duty commercial storage water heaters is now done in terms of UEF instead of thermal efficiency and standby loss (which for the May 2016 CWH ECS NOPR were then converted to UEF). Chapter 5 of the NOPR TSD includes further detail on the engineering analysis.

In choosing the physical and catalog teardown approach over the price survey approach, DOE considered several factors. DOE notes that the sales prices of CWH equipment currently seen in the marketplace, which include both an MPC and various markups applied through the distribution chain, are not necessarily indicative of what the sales prices of those models of CWH equipment would be following the implementation of a more-stringent energy conservation standard. At a given efficiency level, the MPC of CWH equipment depends in part on the production volume. At any given efficiency level above the current baseline, the industry-aggregated MPC for CWH equipment at that level may be high relative to what it would be under a more-stringent standard, due to the increase in production volume (and thus, improved economies of scale and purchasing power for CWH equipment components), which would occur at that level if a Federal standard made it the new baseline efficiency level.

Furthermore, under a more-stringent standard, the markups incorporated into the sales price may change relative to current markups. Therefore, basing the engineering analysis on prices of CWH equipment as currently seen in the marketplace would be a less accurate method of estimating future CWH equipment prices following an amended standard. It is for these reasons that DOE contractors conduct interviews with manufacturers under non-disclosure agreements (''NDAs'') to determine if the MPCs developed by the analysis reflect the industry average cost rather than rely on current sales prices whenever feasible (although as noted above in some cases this approach is not feasible). Because the cost estimation methodology uses data supplied by manufacturers under the NDAs (such as raw material and purchased part prices), the resulting individual model cost estimates themselves cannot be published.

Additionally, while manufacturers of CWH equipment offer both non-condensing and condensing models, condensing equipment is often marketed as a premium product and, therefore, often includes features and capabilities that are not efficiency-related. While such features (*e.g.,* powered anode rods, more sophisticated building management system integration) may be included in condensing equipment currently on the market, these features are not necessary in order to achieve a higher efficiency level, and, therefore, DOE does not believe that the costs for these features should be included in the costs of condensing equipment in the engineering analysis.

The Department must balance transparency and access to information alongside protection of intellectual property and proprietary data. DOE understands that manufacturers would object to having any sensitive information related to the design of their products being released into the public domain. Additionally, DOE notes that all manufacturers that participated in manufacturer interviews conducted in advance of the withdrawn May 2016 CWH ECS NOPR had access to DOE's MPC estimates for models they manufacture that were torn down, as well as the raw material and purchased part price data underlying the MPC estimates for those models. These discussions were covered by NDAs to allow manufacturers to submit confidential data and to comment freely on the inputs into the DOE analysis as well as the results. The MPCs presented in this NOPR take into account the feedback received from manufacturers, which DOE has found to be a valuable tool for ensuring the accuracy of its cost estimates. Without adequate safeguards, manufacturers would likely be unwilling to share information relevant to the rulemaking, which would have correspondingly negative impacts on the rulemaking process.

In the present case, as is generally the case in appliance standards rulemakings, manufacturer and equipment specific data are presented in aggregate. Additionally, prices for raw materials and purchased parts have been updated to the most recent market estimates, in 2020$, to create the current MPCs. Given the potential for competitive harm, data are not released outside the aggregated form (neither publicly, nor to DOE). The BOMs used to estimate the industry-aggregate MPCs are developed by a DOE contractor and are not provided to DOE; DOE only receives the industry-aggregate MPCs from its contractor for use in its analyses. Such aggregated data are used to help populate the analytical spreadsheets for the rulemaking that are publicly available. (DOE notes that it does not typically receive any separate report regarding the aggregated data; therefore, there is no such report available for entry in the rulemaking docket.) This approach allows manufacturers to provide feedback under NDA, improving the quality of the analysis.

3. Representative Equipment for Analysis

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

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

As discussed in sections III.B.6 and IV.C.4.b of this NOPR, DOE did not analyze amended energy conservation standards for electric storage water heaters in this NOPR because manufacturer feedback and DOE's research of equipment on the market indicated that the only technology option analyzed in the withdrawn May 2016 CWH ECS NOPR for decreasing standby loss is already used in some models at the baseline. Consequently, no representative volume was analyzed for electric storage water heaters in this NOPR.

For all CWH equipment categories, the input capacity is also a significant factor for cost and efficiency. Water heaters with higher input capacities typically have higher materials costs and may also have higher labor and shipping costs. Gas-fired storage water heaters with higher input capacities may have additional heat exchanger length to transfer more heat. This leads to higher material costs and may require the tank to expand to compensate for the displaced volume. Gas-fired tankless water heaters, circulating water heaters, and hot water supply boilers require larger heat exchangers to transfer more heat with a higher input capacity. DOE examined input capacities for models in all gas-fired CWH equipment categories to determine representative input capacities. Because the gas-fired instantaneous water heaters and hot water supply boilers equipment class includes several types of equipment that is technologically disparate, DOE selected representative input capacities that would represent both tankless water heaters and circulating water heaters and hot water supply boilers within this broader equipment class. DOE did not receive any shipments data for specific input capacities, and, therefore, DOE considered the number of models at each input capacity in the database of models it compiled (based on DOE's Compliance Certification Database, the AHRI Directory, the CEC Appliance Database, and manufacturer literature), as well as feedback from manufacturer interviews in determining the appropriate representative input capacities for this NOPR. The representative input capacities used in the analyses for this NOPR are shown in Table IV.5.

TABLE IV.5—REPRESENTATIVE STORAGE VOLUMES AND INPUT CAPACITIES

Equipment	Specifications	Representative rated storage volume (gal)	Representative input capacity (kBtu/h)
Commercial gas-fired storage water heaters and gas-fired storage-type instantaneous water heaters *	>105 kBtu/h or >120 gal	100	199
Residential-duty gas-fired storage water heaters **	≤105 kBtu/h and ≤120 gal	75	76
Gas-fired instantaneous water heaters and hot water supply boilers:			
Tankless water heaters	<10 gal		250
Circulating water heaters and hot water supply boilers	All ***		399

* Any commercial gas storage water heater that does not meet the definition of a residential-duty storage water heater is a commercial gas-fired storage water heater regardless of whether it meets the specifications listed.

** To be classified as a residential-duty water heater, a commercial water heater must, if requiring electricity, use single-phase external power supply, and not be designed to heat water at temperatures greater than 180 °F. 79 FR 40542, 40586 (July 11, 2014).

*** For the engineering analysis, circulating water heaters and hot water supply boilers with storage volume <10 gallons and ≥10 gallons were analyzed in the same equipment class. Amended standby loss standards for circulating water heaters and hot water supply boilers with storage volume ≥10 gallons were not analyzed in this NOPR, as discussed in section III.B.7 of this NOPR. Therefore, no representative storage volume was chosen for the instantaneous water heaters and hot water supply boilers equipment class.

The representative volume and input capacities shown in Table IV.5 are the same as those used for the withdrawn May 2016 CWH ECS NOPR. DOE sought comment on the representative CWH equipment used in the engineering analysis in the May 2016 CWH ECS NOPR (81 FR 34440, 34467 (May 31, 2016)), and is including the clarifications in the following subsections in response to the various comments received.

Some commenters expressed concerns regarding the representative input capacity for instantaneous water heaters and hot water supply boilers. (Raypak, No. 41 at p. 7; Spire, No. 45 at pp. 24–25) In response, DOE notes that the representative input capacity is meant to describe the most typical model sold of circulating water heaters and hot water supply boilers. From DOE's market assessment and feedback from manufacturer interviews, DOE has determined that the most frequently sold input capacity of circulating water heaters and hot water supply boilers is 399,000 Btu/h. Additionally, DOE has tentatively determined that a representative capacity of 250,000 Btu/h is appropriate for tankless water heaters. No stakeholders have suggested an alternative input capacity that would be more appropriate for use as the representative input capacity for gas-fired tankless water heaters.

DOE also examined the parts catalogs of circulating water heaters and hot water supply boilers from various manufacturers. From this examination, DOE determined that the same or similar materials, as well as purchased parts, are typically utilized in the manufacture of both representative and larger-capacity circulating water heaters and hot water supply boilers. For example, DOE's market assessment and feedback from manufacturer interviews indicate that the majority of condensing circulating water heaters and hot water supply boilers on the market use purchased condensing heat exchangers. These purchased condensing heat exchangers are typically designed to be modular, so that a larger-capacity unit may include either a larger, similar heat exchanger or multiple similar heat exchangers. Although the amount of material used increases as capacity increases, DOE has not found any evidence that the unit cost of the material would increase due to a lack of economy of scale.

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

DOE research suggests that condensing circulating water heaters and hot water supply boilers with input capacity less than 1 million Btu/h typically do not require more than one premix burner tube or one blower, and that circulating water heaters and hot water supply boilers with input capacity up to 1.7 million Btu/h only require two premix burner tubes and two blowers. Therefore, a condensing circulating water heater or hot water supply boiler with an input capacity of 800,000 Btu/h, twice the representative input capacity, would still include only one premix burner tube and one blower, and a condensing circulating water heater or hot water supply boiler with an input capacity four times the representative input capacity would include only two premix burner tubes and two blowers. While the cost of premix burner tubes does increase with increasing input capacity, feedback from manufacturer interviews indicates that the cost would increase less than linearly with the input capacity. Additionally, within an input range in which circulating water heaters and hot water supply boilers use the same number of premix burner tubes, a larger-capacity unit would utilize the same or similar controls and wiring harness as a smaller input-capacity unit, the cost of which would likely remain fixed regardless of the input capacity. There may be examples of components of certain larger capacity circulating water heaters and hot water supply boilers that may be purchased at a higher cost due to a lack of economy of scale. However, the potential increase in price of any such purchased part would be offset by the many instances in which the production costs remain fixed regardless of input capacity.

For gas-fired storage water heaters and tankless water heaters, DOE expects that the fraction of costs that remain fixed regardless of input capacity would be even higher than for circulating water heaters and hot water supply boilers. Given the smaller input capacity ranges, DOE is not aware of any larger-capacity condensing models in these classes that require more blowers or premix burners than are required in models at the representative capacity. Similar to circulating water heaters and hot water supply boilers, larger-capacity models in these classes would utilize the same controls and wiring harness as smaller-capacity models; thus, the controls and wiring harness costs would remain fixed regardless of the input capacity. Therefore, the representative capacities and corresponding manufacturer production costs used in this analysis appropriately estimate the costs for larger-capacity CWH equipment.

4. Efficiency Levels for Analysis

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

Baseline equipment is used as a reference point for each equipment category in the engineering analysis and the LCC and PBP analyses, which provides a starting point for analyzing potential technologies that provide energy efficiency improvements. Generally, DOE considers ''baseline'' equipment to refer to a model or models having features and technologies that just meet, but do not exceed, the Federal energy conservation standard and provide basic consumer utility.

DOE conducted a survey of its CWH equipment database and manufacturers' websites to determine the highest thermal efficiency levels on the market for each equipment category. DOE identified the most stringent standby loss level for each class by consideration of rated standby loss values of models currently on the market as well as technology options that are feasible but may not currently be included in models on the market in each equipment category.

As discussed in section III.B.1, DOE conducted the analysis for residential-duty gas-fired storage commercial water heaters using UEF rating data, whereas the analysis in the withdrawn May 2016 CWH ECS NOPR analysis was conducted in terms of thermal efficiency and standby loss levels because sufficient data were not available when the rulemaking analysis was initially conducted to conduct the analysis in terms of UEF.

a. Thermal Efficiency Levels

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

TABLE IV.6—BASELINE THERMAL EFFICIENCY LEVELS FOR CWH EQUIPMENT

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

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

DOE established intermediate thermal efficiency levels for each gas-fired equipment category (aside from residential-duty gas-fired storage water heaters, which as noted previously were analyzed using UEF). The intermediate thermal efficiency levels are representative of the most common efficiency levels and those that represent significant technological changes in the design of CWH equipment. For commercial gas-fired storage water heaters and for commercial gas-fired instantaneous water heaters and hot water supply boilers, DOE chose four thermal efficiency levels between the baseline and max-tech levels for analysis. DOE selected the highest thermal efficiency level identified on the market (99 percent) as the ''max-tech'' level for commercial gas-fired storage water heaters and storage-type instantaneous water heaters. For gas-fired instantaneous water heaters and hot water supply boilers, DOE identified hot water supply boilers with thermal efficiency levels of up to 99 percent and tankless instantaneous water heaters with thermal efficiency levels of up to 97 percent available on the market. However, the tankless water heaters with thermal efficiencies of 97 percent were all at a single input capacity and it is unclear whether this thermal efficiency is achievable at other input capacities. As discussed in section IV.A.2.d of this document, DOE analyzed tankless water heaters and circulating water heaters and hot water supply boilers as two separate kinds of representative equipment for this rulemaking analysis, but they are part of the same equipment class (gas-fired instantaneous water heaters and hot water supply boilers). Therefore, because DOE did not find evidence that 97 percent would be an appropriate max-tech level for tankless instantaneous water heaters that is achievable across the range of product inputs currently available, DOE analyzed 96 percent thermal efficiency as the max-tech level for the gas-fired instantaneous water heaters and hot water supply boilers equipment class. The selected thermal efficiency levels used in the current NOPR analysis are shown in Table IV.7.

TABLE IV.7—BASELINE, INTERMEDIATE, AND MAX-TECH THERMAL EFFICIENCY LEVELS FOR REPRESENTATIVE CWH EQUIPMENT

Equipment	Thermal efficiency levels					
	Baseline—E_t EL0 (%)	E_t EL1 (%)	E_t EL2 (%)	E_t EL3 (%)	E_t EL4 (%)	E_t EL5 * (%)
Commercial gas-fired storage water heaters and storage-type instantaneous water heaters	80	82	90	92	95	99
Gas-fired instantaneous water heaters and hot water supply boilers	80	82	84	92	94	96

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

b. Standby Loss Levels

DOE used the current energy conservation standards for standby loss to set the baseline standby loss levels. Table IV.8 shows these baseline standby loss levels for representative commercial gas-fired storage water heaters and storage-type instantaneous water heaters. In the withdrawn May 2016 CWH ECS NOPR, DOE also identified baseline standby loss levels for electric storage water heaters. 81 FR 34440, 34443 (May 31, 2016). However, as discussed in this section and section III.B.6 of this NOPR, DOE did not further analyze amended standards for electric storage water heaters in this NOPR because of manufacturer feedback and DOE research of equipment on the market indicating that the only analyzed technology option for decreasing standby loss is already used in some units at the baseline.

TABLE IV.8—BASELINE STANDBY LOSS LEVELS FOR REPRESENTATIVE CWH EQUIPMENT

Equipment	Representative rated storage volume (gal)	Representative input capacity (kBtu/h)	Baseline standby loss level (Btu/h)
Commercial gas-fired storage water heaters and storage-type instantaneous water heaters	100	199	1,349

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

Therefore, DOE analyzed technology options commonly used on the market to help guide its selection of standby loss levels. To inform the selection of standby loss levels for the withdrawn May 2016 CWH ECS NOPR, DOE performed heat loss calculations for representative equipment to estimate how more-stringent standby loss levels correspond to the identified technology options. Chapter 5 of the May 2016 CWH ECS NOPR TSD provides details on these heat loss calculations. Because DOE used heat loss calculations corresponding to commonly used technology options to inform the selection of standby loss levels for the May 2016 CWH ECS NOPR in addition to rated standby loss market data, the most stringent standby loss levels analyzed did not necessarily reflect the current market max-tech level for each equipment category. However, as described later in this section, DOE did not analyze improved tank insulation as a technology option for reducing standby loss in this NOPR because such insulation improvements would not be a viable standby loss reducing option for all models on the market. Therefore, DOE did not use tank heat loss calculations to determine standby loss levels in this NOPR. The technology options analyzed and selection of max-tech levels are discussed in the following sections for each equipment category.

In addition to the potential to reduce standby losses using technology options, for commercial and residential-duty gas-fired storage water heaters, standby loss is also reduced by increasing thermal efficiency. Standby loss is measured in the test procedure predominantly as a function of the fuel used to heat the stored water during the standby loss test, with a small contribution of electric power consumption (if the unit requires a power supply). Because standby loss is calculated using the fuel consumed during the test to maintain the water temperature, the standby loss is dependent on the thermal efficiency of the water heater. DOE used data from independent testing of CWH equipment at a third-party laboratory to estimate the fraction of standby loss that can be attributed to fuel consumption or electric power consumption. DOE then scaled down (*i.e.,* made more stringent) the portion of the standby loss attributable to fuel consumption as thermal efficiency increased to estimate the inherent improvement in standby loss associated with increasing thermal efficiency. Chapter 5 of the NOPR TSD explains these calculations, and the interdependence of thermal efficiency (''E_t'') and standby loss (''SL'') are explained in more detail. However, for condensing thermal efficiency levels for residential-duty gas-fired storage water heaters, DOE did not include dependence on thermal efficiency in its standby loss levels, as discussed further later in this section.

Standby loss levels for each equipment category are shown in the following sections in terms of Btu/h for the representative equipment. However, to analyze potential amendments to the current Federal standard, factors (''standby loss reduction factors'') were developed to multiply by the current maximum standby loss equation for each equipment class, based on the ratio of standby loss at each efficiency level to the current standby loss standard. The translation from standby loss values to maximum standby loss equations is described in further detail in section IV.C.5 of this NOPR.

1. Heat Loss Calculations in the May 2016 CWH ECS NOPR

For the withdrawn May 2016 CWH ECS NOPR, DOE used heat loss calculations to determine the standby loss reduction from technology options used on the market because other options (including those suggested by manufacturers in response to the NOPR and discussed as follows) were not feasible. As previously discussed, manufacturers typically do not disclose the presence of standby loss reducing technology options in public literature. Additionally, the testing and/or tearing down of units currently on the market would only help inform the determination of standby loss reduction of technology options if DOE could isolate the effect of each individual technology option. However, DOE is unaware of any manufacturer that offers commercial or residential-duty storage water heater models that are completely identical except for one specific standby-loss-reducing technology option. Therefore, DOE would not reliably be able to determine to what extent (if at all) design difference(s) between two different storage water heaters contribute to the difference in standby loss. For example, two storage water heaters on the market at the same representative capacity might differ in any or all of the following respects that could affect the standby loss: Tank dimensions, numbers and/or sizes of fittings and connections, heat exchanger surface area, insulation type and thickness, and coverage of the tank (including tank walls, top, and bottom) with foam insulation. Therefore, DOE initially concluded in the May 2016 CWH ECS NOPR that neither testing nor tearing down of storage water heaters on the market would allow DOE to reliably select standby loss levels or determine the technological pathway and manufacturing costs for manufacturers to achieve those levels, and instead performed heat loss calculations to estimate the standby loss reductions. The heat loss calculations are described in detail in the May 2016 NOPR TSD.

In response to the May 2016 CWH ECS NOPR, DOE received comments from several stakeholders expressing concerns about DOE's heat loss calculations. For example, Rheem argued that DOE's calculation methodologies are incorrect because the proposed standby loss levels in the NOPR are not achieved by models currently on the market that use the analyzed standby-loss-reducing technology options. (Rheem, No. 43 at p. 20) Rheem further stated that the maximum standby loss requirements proposed in the May 2016 CWH ECS NOPR cannot be achieved for every tank size of commercial storage water heater with the technology options that DOE analyzed for the representative volume. (Rheem, No. 43 at p. 14)

Bock argued that the proposed standby loss levels are not representative of the capabilities of the analyzed technology options. (Bock, No. 33 at pp. 3–4) A.O. Smith argued that DOE must not establish standby loss standards based on theoretical values that have not been validated. (A.O. Smith, No. 39 at pp. 9–10) AHRI also suggested that DOE is speculating costs of products that either do not exist or are produced by specialty companies, which is a departure from DOE's longstanding practice of not including such products in its analysis. (AHRI, No. 40 at p. 20) Bradford White disagreed with DOE's approach of using theoretical calculations to determine the proposed standby loss levels. (Bradford White, No. 42 at p. 14)

A.O. Smith commented that DOE incorrectly assumed that heat loss has a linear relationship based on the R-value of the insulation multiplied by the thickness of the insulation. Instead, A.O. Smith argued that the relationship between heat loss and insulation thickness is non-linear and that foam insulation reaches a maximum effective thickness before experiencing diminishing returns. A.O. Smith also stated that there are design and engineering limitations as to where insulation can be applied on the water heater. (A.O. Smith, No. 39 at pp. 9–10)

DOE recognizes manufacturers' concerns regarding the use of theoretical calculations to inform the selection of standby loss levels, the feasibility of achieving DOE's proposed standby loss levels with the analyzed technology options, and the lack of models currently on the market that meet DOE's proposed standby loss levels. DOE also recognizes Rheem's concerns regarding the proposed standby loss levels not being achievable for all tank volumes of storage water heaters and storage-type instantaneous water heaters. In large part, DOE's subsequent analysis of models on the market agrees with these comments in that DOE found few models that meet the proposed standby loss levels, and it is not clear that the proposed levels could be met with the analyzed technology options across the range of storage volumes on the market. In light of these comments, DOE has made several changes to its standby loss level analysis for this NOPR. First, DOE adjusted the technology options that correspond to the standby loss baseline (*i.e.,* the technology options that DOE assumes are used to meet the current standby loss standard) based on stakeholder comments. Second, because of the adjustment in technology options analyzed at the baselines, DOE did not analyze improved tank insulation as a technology option for reducing standby loss. Third, because of comments indicating that there are no technology options that reliably decrease standby loss beyond the baseline for electric storage water heaters, DOE did not analyze amended standby loss standards for electric storage water heaters. All of these changes to the analysis are based on comments received for the May 2016 CWH ECS NOPR and are further discussed later in this section.

For all commercial gas-fired storage water heater levels, the only standby loss reduction analyzed corresponds to the inherent standby loss reduction from increasing thermal efficiency. (DOE notes that for non-condensing residential-duty gas-fired storage water heaters, an electromechanical flue damper and electronic ignition were considered which would improve UEF by reducing standby losses. This is discussed further in section IV.C.4.c. of this document) DOE research regarding rated standby loss values showed that the vast majority of models at a given thermal efficiency level already meet the standby loss level associated with the standby loss reduction factor being applied for that level. In addition, because the vast majority of models on the market that meet each thermal efficiency level being analyzed also meet the corresponding standby loss level, further validating the standby loss levels by testing models on the market or by building water heater prototypes is not necessary and was not done for this NOPR.

2. Reduction in Standby Loss Associated With Increased Thermal Efficiency

In the May 2016 CWH ECS NOPR, DOE stated that, for gas-fired storage water heaters, standby loss is a function of storage volume and input rate and is affected by many aspects of the design of a water heater. Further, because standby loss is calculated using the fuel consumed during the test to maintain the water temperature, the standby loss is dependent on the thermal efficiency of the water heater. DOE also suggested that variation in reported standby loss values may be partially attributed to undisclosed technology options (including insulation type and thickness, and baffle design) and sources of variation in the current standby loss test procedure. 81 FR 34440, 34470.

In response to the May 2016 CWH ECS NOPR, commenters questioned the certainty of the relationship between standby loss and thermal efficiency portrayed in DOE's analysis. (*See* Rheem, No. 43 at p. 16; Bradford White, No. 42 at p. 6) In response, DOE notes that although it is true that actual heat losses are largely dependent on tank insulation, fittings, and flue openings, there is also an important distinction to be made between heat loss from the tank and standby loss measured as a function of fuel flow. Increased thermal efficiency does not necessarily affect heat loss from the tank, but it inherently decreases the amount of fuel consumed to reheat the stored water, and thus decreases measured standby loss. Accounting for this inherent difference does not ignore or understate the impacts of water heater design on standby loss.

DOE also recognizes that heat exchangers in non-condensing and condensing storage water heater have different geometries and surface areas. However, DOE's research suggests that many condensing models currently on the market include 1 inch of foam insulation, similar to many baseline non-condensing commercial gas-fired storage water heaters, indicating that the lower standby loss of the condensing models relative to the non-condensing models likely comes as a result of their higher thermal efficiency and condensing heat exchanger designs.

DOE notes that the fact that the vast majority of models on the market already achieve the standby loss decreases that are inherent to increased thermal efficiency from condensing operation using a wide variety of heat exchanger designs (*e.g.,* multi-pass and helical condensing heat exchangers with either a top-fired, side-fired, or bottom-fired configuration [33]) indicates that there are a variety of design paths available to manufacturers to achieve this standby loss reduction. Therefore, DOE maintained its approach to include a dependence of standby loss levels on thermal efficiency in this NOPR. Chapter 5 of the NOPR TSD includes further detail on the dependence of standby loss on thermal efficiency and on the corresponding analysis of models currently on the market.

3. Commercial Gas-Fired Storage Water Heaters and Gas-Fired Storage-Type Instantaneous Water Heaters Technology Options

For commercial gas-fired storage water heaters, DOE preliminarily determined in the May 2016 CWH ECS NOPR analysis that the current minimum Federal standard can be met with installation of 1 inch of fiberglass insulation around the walls of the tank. In the standby loss analysis, DOE considered baseline non-condensing equipment to include electromechanical flue dampers and all condensing equipment to include mechanical draft systems, both of which act to reduce standby losses out the flue. 81 FR 34440, 34470 (May 31, 2016).

In the May 2016 CWH ECS NOPR analysis, DOE then considered the next incremental standby loss level to correspond to the use of 1 inch of sprayed polyurethane foam insulation instead of fiberglass insulation. From DOE's market assessment and manufacturer interviews, DOE found the highest insulation thickness available for commercial gas-fired water heaters to be 2 inches. Therefore, DOE considered the next incremental standby loss level to correspond to 2 inches of polyurethane foam. While more-stringent standby loss levels than the max-tech standby loss level analyzed in the May 2016 CWH ECS NOPR exist on the market, these more-stringent values are only rated for condensing models with specific heat exchanger designs. To avoid mandating specific heat exchanger designs for achieving condensing thermal efficiency levels, DOE considered the max-tech standby loss level to correspond to 2 inches of foam insulation in the May 2016 CWH ECS NOPR. *Id.*

In response to the May 2016 CWH ECS NOPR, A.O. Smith stated that DOE overestimated the max-tech standby loss levels for gas-fired storage water heaters. (A.O. Smith, No. 39 at p. 9) A.O. Smith and Bradford White disagreed with DOE's assertion that the current standby loss standard can be met with 1 inch of fiberglass insulation and with DOE's consideration of this technology option as the baseline standby loss technology for commercial gas-fired storage water heaters. Rather, A.O. Smith and Bradford White argued that models available on the market typically use a combination of fiberglass and sprayed polyurethane foam. (A.O. Smith, No. 39 at p. 10; Bradford White, No. 42 at p. 5) A.O. Smith further argued that if DOE's proposed max-tech standby loss level

[33] In a multi-pass condensing heat exchanger design, the flue gases are forced through flue tubes that span the length of the tank multiple times. Typically, the flue gases are re-directed back through the tank via return plenums located above and/or below the tank. Top-fired, side-fired, and bottom-fired refer to the configuration of the burner assembly (consisting of a gas valve, blower, and premix burner tube) in a condensing gas-fired storage water heater. In a top-fired configuration, the premix burner assembly is located at the top of the tank and fires down into the heat exchanger. In a side-fired configuration, the burner assembly is located on the side of the tank. In a bottom-fired configuration, the burner assembly is located below the tank and fired up into the heat exchanger.

were adopted, it would result in a significant reduction of models available on the market, which would impact competition and pricing. A.O. Smith asserted that DOE does not appreciate the engineering complexity and costs involved in meeting the proposed standby loss standard. A.O. Smith further stated that minimizing heat loss through a heat exchanger while the water heater is in standby mode has a direct and significant correlation to standby loss, and that the methods of reducing standby loss through the heat exchanger are complicated and require use of mechanical draft and changes in controls or heat exchanger geometry. (A.O. Smith, No. 39 at p. 10) A.O. Smith also argued that the current ENERGY STAR standby loss level (*i.e.,* corresponding to a standby loss reduction factor of 0.84) is representative of max-tech technology. (A.O. Smith, No. 39 at p. 11)

Rheem stated that the standby loss level proposed in the May 2016 CWH ECS NOPR cannot be met using the analyzed technology option of 2-inch foam insulation because there is significant heat loss from uninsulated areas of the tank (*e.g.,* fittings). (Rheem, No. 43 at p. 18) Bradford White stated that it was unable to identify any commercial gas-fired storage water heater models at the representative capacities (*i.e.,* 199,000 Btu/h input capacity and 100 gallons rated volume) currently available on the market that meet the max-tech standby level or even some of the intermediate standby loss levels. Bradford White also commented that while some lower-capacity models may meet these standby loss levels, it would be unfair to include them in the analysis for the representative equipment. Bradford White also asserted that the technology options DOE used to select the standby loss levels in the May 2016 CWH ECS NOPR are already used in equipment currently on the market. (Bradford White, No. 42 at pp. 5–6) Bock stated that none of Bock's condensing gas-fired storage models would meet DOE's proposed standby loss standard, even though these models use the technology options that DOE assumes are sufficient to meet the proposed standard. (Bock, No. 33 at p. 1)

In light of comments received regarding the technology options used for baseline models and subsequent DOE research of equipment on the market, DOE agrees that many commercial gas-fired storage water heaters rated at or near the current standby loss standard use a combination of fiberglass and polyurethane foam insulation. Specifically, many models have fiberglass insulation near the bottom of the tank and around fittings and connections, and polyurethane foam insulation covering the rest of the tank walls. DOE acknowledges that changing from 1 inch of fiberglass insulation to 1 inch of foam insulation is not a viable standby-loss-reducing technology option for some models on the market rated at or near the current standby loss standard because they already have 1 inch of foam insulation. Additionally, DOE recognizes that there is significant variation in standby loss ratings for models currently on the market—such that an increase from 1 inch to 2 inches of foam insulation does not necessarily allow all models within a model line to achieve the incremental standby levels corresponding to foam insulation analyzed for the May 2016 CWH ECS NOPR. Specifically, not all models within a model line can necessarily meet a given standby loss level (*i.e.,* standby loss reduction factor, see section IV.C.4.c of this NOPR) with the same insulation thickness. Additionally, stakeholder comments and DOE's research suggest that many commercial gas-fired storage water heaters with standby loss values at or near the current standby loss standard already have foam insulation thicknesses greater than 1 inch. Therefore, increasing foam insulation thickness from 1 inch to 2 inches is also not a viable standby-loss-reducing technology option for some models on the market. Consequently, in this NOPR, DOE did not analyze increasing insulation thickness for commercial gas-fired storage water heaters. The only level of standby loss reduction analyzed for commercial gas-fired storage water heaters in this NOPR corresponds to the standby loss reduction inherent to an increase in thermal efficiency (as discussed previously in this section). Because the analyzed standby loss levels only correspond to the standby loss reduction inherent to achieving each thermal efficiency, DOE expects that at the standby loss levels analyzed, heat exchanger modifications would not be required to meet any of the standby loss levels analyzed for this NOPR.

DOE further notes that all commercial gas-fired storage water heaters that DOE identified on the market have either an electromechanical flue damper (non-condensing models) or mechanical draft technology (condensing models). For the May 2016 CWH ECS NOPR, DOE assumed an equivalent standby loss reduction between these two technologies. The baseline standby loss level reflects use of a flue damper (*i.e.,* the baseline standby loss level is based on non-condensing models). When evaluating condensing thermal efficiency levels, DOE assumed the impact to standby loss from the use of a flue damper, which is not used in condensing models, is equal to the impact from use of mechanical draft.

DOE notes that in the analysis for both the May 2016 CWH ECS NOPR and this NOPR, DOE included the increased standby electrical consumption associated with condensing technology in its determination of the fraction of standby loss attributable to fuel consumption. Chapter 5 of the NOPR TSD includes further detail on the consideration of standby losses from electricity consumption.

DOE recognizes that the primary function of a blower is to propel flue gases as part of a mechanical draft system. However, the fact that it is not the primary function of a blower to restrict flue losses does not necessarily mean that a blower does not have the effect of restricting such flue losses. Similar to a flue damper, a blower sits on the top of the heat exchanger and is a barrier to prevent hot air from rising out of the flue(s) during standby mode. Therefore, in its analysis of the dependence of standby loss on thermal efficiency, DOE maintained its assumption that a blower would provide a similar level of flue loss reduction to that of an electromechanical flue damper. Correspondingly, DOE did not assume any change in flue loss reduction when moving from non-condensing to condensing thermal efficiency levels. This assumption is validated by the previously discussed observation that the majority of condensing commercial gas-fired storage water heaters currently on the market already achieve the inherent standby loss reduction associated with the thermal efficiency increases resulting from condensing operation. As discussed in section IV.C.6 of this NOPR and chapter 5 of the NOPR TSD, DOE's teardown analysis and feedback from manufacturer interviews indicate that blowers are required for condensing operation.

In the May 2016 CWH ECS NOPR TSD, in the context of comparing the standby loss reduction from a flue damper for commercial gas-fired storage water heaters and consumer gas-fired storage water heaters, DOE stated that many commercial water heaters have multiple vented flue pipes, meaning that there is significantly more opportunity for standby loss reduction from a flue damper in commercial water heaters than in consumer water heaters. (Docket No. EERE–2014–BT–STD–

0042–0016 at p. 5–15 [34]) To further clarify, this statement was comparing the standby losses of a consumer gas-fired storage water heater to those of a commercial gas-fired storage water heater. DOE noted that the flue losses would comprise a larger share of total standby loss for a commercial gas-fired storage water heater than for a consumer gas-fired storage water heater. One of DOE's justifications for this argument was that many commercial gas-fired storage water heaters have multiple vented flue pipes, while consumer gas-fired storage water heaters typically only have one flue pipe. DOE clarifies that the phrase ''multiple vented flue pipes'' was meant to refer to multiple flue pipes that exhaust flue gases outside of the tank, though all the flue gases may pass through a collector that has a single outlet to the vent system. Additionally, DOE's intended position was that multiple vented flue pipes would have a higher heat exchanger surface area over which heat can be lost from the stored water when in standby mode.

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

TABLE IV.9—STANDBY LOSS LEVELS FOR COMMERCIAL GAS-FIRED STORAGE WATER HEATERS AND STORAGE-TYPE INSTANTANEOUS WATER HEATERS, 100 GALLON RATED STORAGE VOLUME, 199,000 Btu/h INPUT CAPACITY

Thermal efficiency level	Thermal efficiency (%)	Standby loss (Btu/h)
E_t EL0	80	1349
E_t EL1	82	1316
E_t EL2	90	1223
E_t EL3	92	1197
E_t EL4	95	1160
E_t EL5	99	1115

4. Electric Storage Water Heaters Technology Options

In the withdrawn May 2016 CWH ECS NOPR analysis for electric storage water heaters, DOE determined that the current Federal standard can be met through use of 2 inches of polyurethane foam insulation. Therefore, this design was selected to represent the baseline standby loss level. The more-stringent standby loss level that DOE considered, representing the max-tech efficiency level, corresponded to 3 inches of polyurethane foam insulation.

In response to the May 2016 CWH ECS NOPR, AHRI and A.O. Smith stated that no electric storage water heater models on the market at that time met the proposed standby loss standard. (AHRI, No. 40 at p. 16; A.O. Smith, No. 39 at p. 4) AHRI stated that while DOE has put forward possible engineering paths to reach its proposed standby loss levels, there is no direct manufacturing experience to demonstrate either that these levels can be met in practice or that these levels can be met at the costs projected by DOE. (AHRI, No. 40 at p. 17)

Several commenters suggested that DOE's standby loss calculations overestimate the reduction in standby loss for given technology options for electric storage water heaters. (Bock, No. 33 at p. 4; A.O. Smith, No. 39 at p. 9; Bradford White, No. 42 at p. 7; Rheem, No. 43 at p. 17) A.O. Smith and Bradford White stated that DOE's analyzed technology option for reducing standby loss (*i.e.,* using 3 inches of foam insulation) is already utilized in some electric storage water heaters on the market to meet the current standby loss standard. (A.O. Smith, No. 39 at p. 4; Bradford White, No. 42 at p. 7) A.O. Smith and Rheem commented that there are several models on the market with 3 inches of foam insulation, and none of these models meet the proposed standby loss limits. (A.O. Smith, No. 39 at p. 9; Rheem, No. 43 at p. 17)

Rheem argued that consideration of water heater design was absent from DOE's analysis, and that there should have been a comparison with actual models to validate the theoretical calculations. (Rheem, No. 43 at p. 17)

A.O. Smith argued that DOE created a theoretical max-tech level without explaining whether testing, research, and/or other analysis were performed to validate its theoretical standby loss level. A.O. Smith also argued that DOE has the burden to demonstrate that the proposed level can be achieved. (A.O. Smith, No. 39 at p. 9) EEI requested that DOE clarify whether the proposed 16-percent reduction in standby loss for electric storage water heaters is achievable for larger-volume models. EEI added that commercial electric storage water heaters are sized as large as 10,000 gallons and questioned whether DOE's proposed standby loss reduction is possible for these larger water heaters that have more fittings and surface area (EEI, Public Meeting Transcript, No. 20 at pp. 38–40) AHRI suggested that the standby loss reduction analyzed for electric storage water heaters with 119 gallons storage volume might not scale well for models with storage volume less than 50 gallons, and that these lower-volume models might be adversely affected by DOE's proposed standby loss standard. (AHRI, No. 40 at p. 9)

In light of comments received and DOE's market research, DOE recognizes that some electric storage water heater models currently on the market with 3 inches of foam insulation have a rated standby loss at or near the current standard. Because these models already have 3 inches of foam insulation, the standby loss reduction that DOE attributed to using 3 inches of foam insulation in the May 2016 CWH ECS NOPR would not be achievable for these models using DOE's analyzed technology option. Therefore, in this NOPR, DOE analyzed 3 inches of polyurethane foam insulation as the technology option used to achieve the current standby loss standard. However, 3 inches of foam insulation is also the max-tech technology option, and DOE did not consider any additional technology options for the reduction of standby loss for electric storage water heaters. Therefore, in this NOPR, DOE did not further analyze and is not adopting amended standby loss standards for electric storage water heaters.

c. Uniform Energy Efficiency Levels

As discussed in III.B.1 of this NOPR, DOE conducted all analyses of potential amended standards for residential-duty commercial water heaters in this document in terms of UEF to reflect the current test procedure and metric. However, the withdrawn May 2016 CWH ECS NOPR analysis was conducted in terms of the previous thermal efficiency and standby loss metrics because there were insufficient efficiency data in terms of UEF available when DOE undertook the initial analyses for this proposed rulemaking.

In the May 2016 CWH ECS NOPR analysis for residential-duty gas-fired storage water heaters, DOE previously determined that the Federal standards can be met through use of 1 inch of polyurethane foam insulation. From surveying commercially-available equipment, DOE also determined that all baseline residential-duty gas-fired storage water heaters have a standing pilot and do not use flue dampers. Therefore, in addition to considering increased foam insulation thickness, DOE also considered electromechanical

[34] Page 5–15 of the May 2016 CWH ECS NOPR TSD is page 101 of the document PDF file.

flue dampers and electronic ignition as technology options for improving efficiency. Electromechanical flue dampers were only considered as a technology option for non-condensing residential-duty gas-fired storage water heaters, because flue dampers are not used with mechanical draft systems and condensing water heaters use mechanical draft systems. Therefore, for residential-duty gas-fired storage water heaters, DOE considered electromechanical flue dampers to be a technology option to improve efficiency for non-condensing equipment and considered mechanical draft systems to be featured in all condensing equipment. Both of these technologies improve efficiency by reducing standby losses through the flue during periods when the burner is not operating. Additionally, because all condensing residential-duty gas-fired storage water heaters include electronic ignition, DOE only considered electronic ignition as a technology option for non-condensing residential-duty gas-fired storage water heaters.

In response to the May 2016 CWH ECS NOPR, Bradford White commented that for residential-duty gas-fired storage water heaters, in most cases, 2 inches of polyurethane foam insulation are required to meet the current Federal standard, rather than 1 inch as assumed by DOE in the NOPR. (Bradford White, No. 42 at p. 7)

DOE acknowledges Bradford White's comment that some residential-duty gas-fired storage water heaters with rated standby loss values at or near the current standard (now in terms of UEF rather than standby loss) have 2 inches of polyurethane foam insulation. Because these baseline or near-baseline models already have 2 inches of foam insulation, DOE considered 2 inches of polyurethane foam insulation as a baseline technology option for residential-duty gas-fired storage water heaters, and did not consider any efficiency gains associated with increased insulation.

As previously discussed, electromechanical flue dampers and electronic ignition were only considered as a technology option for non-condensing equipment. Technology options that would specifically decrease standby losses were not considered for condensing residential-duty gas-fired storage water heaters (for which the baseline includes 2 inches of foam insulation and electronic ignition and for which electromechanical flue dampers are not an appropriate technology option). (Even though standby losses are no longer measured directly for residential-duty gas-fired storage water heaters, standby losses still contribute to UEF.)

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

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

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

TABLE IV.10—BASELINE, INTERMEDIATE, AND MAX-TECH UEF LEVELS FOR RESIDENTIAL-DUTY GAS-FIRED STORAGE WATER HEATERS

UEF level	Incremental step increase	UEF (high draw pattern) *
EL0—Baseline	0	$0.6597 - (0.0009 \times V_r)$
EL1	0.02	$0.6797 - (0.0009 \times V_r)$
EL2	0.09	$0.7497 - (0.0009 \times V_r)$
EL3	0.18	$0.8397 - (0.0009 \times V_r)$
EL4	0.27	$0.9297 - (0.0009 \times V_r)$
EL5	0.34	$0.9997 - (0.0009 \times V_r)$

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

5. Standby Loss Reduction Factors

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

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

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

Eq. 1

In order to consider amended standby loss standards for commercial gas-fired storage water heaters, DOE needed to revise the current standby loss standard equation to correspond to the decreased standby loss value, in Btu/h, determined for the representative capacity. In the withdrawn May 2016 CWH ECS NOPR, DOE considered revising the standby loss equations for gas-fired and electric storage water heaters. 81 FR 34440, 34476–34477 (May 31, 2016). However, as discussed in sections III.B.6 and IV.C.4.b of this NOPR, DOE is not proposing to amend the standby loss standard for electric storage water heaters.

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

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

TABLE IV.11—STANDBY LOSS REDUCTION FACTORS FOR COMMERCIAL GAS-FIRED STORAGE WATER HEATERS

Thermal efficiency level	Thermal efficiency (%)	Standby loss reduction factor
E_t EL0	80	1.00
E_t EL1	82	0.98
E_t EL2	90	0.91
E_t EL3	92	0.89
E_t EL4	95	0.86
E_t EL5	99	0.83

6. Teardown Analysis

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

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

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

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

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

TABLE IV.12—TECHNOLOGIES IDENTIFIED AT EACH THERMAL EFFICIENCY LEVEL FOR COMMERCIAL GAS-FIRED STORAGE WATER HEATERS

Thermal efficiency level	Thermal efficiency (%)	Design changes *
E_t EL0	80	
E_t EL1	82	Increased heat exchanger area.
E_t EL2	90	Condensing heat exchanger, forced draft blower, premix burner.
E_t EL3	92	Condensing heat exchanger, forced draft blower, premix burner, increased heat exchanger surface area.
E_t EL4	95	Condensing heat exchanger, forced draft blower, premix burner, increased heat exchanger surface area.
E_t EL5	99	Condensing heat exchanger, forced draft blower, premix burner, increased heat exchanger surface area.

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

TABLE IV.13—TECHNOLOGIES IDENTIFIED AT EACH THERMAL EFFICIENCY LEVEL FOR RESIDENTIAL-DUTY GAS-FIRED STORAGE WATER HEATERS

UEF level	UEF (high draw pattern) *	Design changes **
EL0—Baseline	$0.6597 - (0.0009 \times V_r)$.	
EL1	$0.6797 - (0.0009 \times V_r)$	Increased heat exchanger area.
EL2	$0.7497 - (0.0009 \times V_r)$	Electronic ignition, electromechanical flue damper or power venting; increased heat exchanger area.
EL3	$0.8397 - (0.0009 \times V_r)$	Electronic ignition; condensing heat exchanger; power venting.
EL4	$0.9297 - (0.0009 \times V_r)$	Electronic ignition; condensing heat exchanger; power venting; premix burner; increased heat exchanger area.
EL5	$0.9997 - (0.0009 \times V_r)$	Electronic ignition; condensing heat exchanger; power venting; premix burner; increased heat exchanger area.

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

TABLE IV.14—TECHNOLOGIES IDENTIFIED AT EACH THERMAL EFFICIENCY LEVEL FOR GAS-FIRED TANKLESS WATER HEATERS

Thermal efficiency level	Thermal efficiency (%)	Design changes *
E_t EL0	80	
E_t EL1	82	Increased heat exchanger area.
E_t EL2	84	Increased heat exchanger area.
E_t EL3	92	Secondary condensing heat exchanger.
E_t EL4	94	Secondary condensing heat exchanger, increased heat exchanger surface area.
E_t EL5	96	Secondary condensing heat exchanger, increased heat exchanger surface area.

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

TABLE IV.15—TECHNOLOGIES IDENTIFIED AT EACH THERMAL EFFICIENCY LEVEL FOR GAS-FIRED CIRCULATING WATER HEATERS AND HOT WATER SUPPLY BOILERS

Thermal efficiency level	Thermal efficiency (%)	Design changes *
E_t EL0	80	
E_t EL1	82	Increased heat exchanger area.
E_t EL2	84	Increased heat exchanger area, induced draft blower.
E_t EL3	92	Condensing heat exchanger, forced draft blower, premix burner.
E_t EL4	94	Condensing heat exchanger, forced draft blower, premix burner, increased heat exchanger surface area.
E_t EL5	96	Condensing heat exchanger, forced draft blower, premix burner, increased heat exchanger surface area.

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

From surveying models currently on the market, DOE determined that the only design change for many efficiency levels is an increased heat exchanger surface area. Based upon heat exchanger calculations and feedback from manufacturer interviews, DOE determined a factor by which heat exchangers would need to expand to reach higher thermal efficiency levels. This factor was higher for condensing efficiency levels than for non-condensing efficiency levels. Chapter 5 of the NOPR TSD provides more information on these heat exchanger sizing calculations, as well as on the technology options DOE considered at each efficiency level.

In response to the May 2016 CWH ECS NOPR, DOE received comments from stakeholders questioning the typical design features assumed in DOE's analysis. For example, Bradford White stated that manufacturers must use more anode rods on products with more flues (*i.e.,* higher thermal efficiency) to ensure the product is sufficiently protected against corrosion. (Bradford White, No. 42 at p. 7)

Lochinvar commented that in determining manufacturer production cost, DOE should take into consideration that condensing equipment requires costlier, corrosion-resistant material. In addition, Lochinvar stated that use of such corrosion-resistant material means condensing equipment may not need anode rods. Lochinvar further stated that anode rods are required for condensing equipment that is built from less expensive, corrosive materials. (Lochinvar, Public Meeting Transcript, No. 20 at p. 44)

In the May 2016 CWH ECS NOPR analysis, DOE assumed that the number of anode rods is independent of efficiency and, thus, analyzed the same number of anode rods across all efficiency levels for each storage water heater class. However, DOE recognizes that the welds inside a storage water heater are typically the primary source of concern for corrosion inside a storage water heater. As stated by Bradford White, a condensing gas-fired storage water heater with a multi-pass heat exchanger design[35] will typically have more flue pipes and, therefore, more welds (joining the flue pipe and tank top or bottom) than would a non-condensing gas-fired storage water heater. Therefore, DOE acknowledges that condensing gas-fired storage water heaters may require an additional anode rod to compensate for the additional welds, relative to a non-condensing gas-fired storage water heater. To reflect this possibility, DOE included the costs of an additional anode rod for residential-duty and commercial gas-fired storage water heaters with a multi-pass condensing heat exchanger design. In response to Lochinvar, DOE included the cost of anode rods in its cost estimates for storage water heaters if the tank and heat exchanger are not constructed entirely from corrosion-resistant materials (*e.g.,* stainless steel or cupronickel), but did not include the cost of anode rods for designs where the tank and heat exchanger are constructed of corrosion-resistant alloys. Manufacturer literature for storage water heaters constructed with stainless steel tanks and heat exchangers indicate that such models do not require anode rods for corrosion protection. Chapter 5 of the NOPR TSD includes further detail on the number of anode rods DOE analyzed to develop cost estimates for storage water heaters.

In addition, DOE notes that many condensing gas-fired storage water heaters currently on the market are often marketed as premium products and include non-efficiency-related features. Some of these features, such as built-in diagnostics and run history information, may require user interfaces, but a user interface is not necessary for operation of a condensing gas-fired storage water heater. DOE research suggests that condensing appliances may feature as little as a push button and several light-emitting diodes on the control board to communicate the status of the unit, error codes, and so on. Some condensing models on the market also include modulating burners and gas valves, which do require more sophisticated controls. However, modulation is not required to achieve condensing operation for gas-fired storage water heaters and does not affect efficiency as measured by DOE's test procedure, and DOE notes that many condensing gas-fired storage water heaters currently on the market do not include modulating combustion systems or the corresponding more sophisticated controls. While a condensing combustion assembly (comprising a gas valve, blower, and premix burner) may require calibration by the manufacturer (the costs for which DOE accounts in its development of cost estimates), DOE does not believe that a technician would need a user interface included within the water heater to service a gas-fired storage water heater with a non-modulating combustion assembly. In order to accurately assess the costs of adopting a more-stringent standard, DOE only considers costs of components that are necessary for models to achieve each efficiency level as measured by DOE's test procedure. Therefore, DOE does not include the costs of features such as modulation, more sophisticated controls, and powered anode rods. Chapter 5 of the NOPR TSD includes further detail on the exclusion of costs for non-efficiency-related features from DOE's MPC estimates.

In the May 2016 CWH ECS NOPR TSD, in the context of assessing market standby loss data for commercial gas-fired storage water heaters, DOE stated that, relative to non-condensing models, many condensing models tend to have fewer flue pipes that vent because the

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

flue gas must follow a longer path within the heat exchanger to begin condensation. DOE further stated that because there are fewer pipes that vent outside the water heater in most condensing models than in non-condensing models, less heat is lost out of these pipes in standby mode. DOE also mentioned that standby loss for condensing models would generally be lower than for non-condensing models because standby loss is in large part dependent on thermal efficiency, because standby loss is calculated using fuel flow to the burner during the test period. (Docket No. EERE–2014–BT–STD–0042–0016 at pp. 3–21) [36] This statement appears to have caused confusion among stakeholders as to DOE's assumptions about typical condensing heat exchanger designs.

To clarify, DOE notes that, as stated in chapter 5 of the withdrawn May 2016 CWH ECS NOPR TSD, DOE did not assume that manufacturers will switch from their current condensing heat exchanger designs to a helical condensing heat exchanger design. (Docket No. EERE–2014–BT–STD–0042–0016 at pp. 5–21) [37] In the engineering analysis, DOE assumed that manufacturers would continue making condensing gas-fired storage water heaters with heat exchangers similar in design to those included in their current product offerings. Therefore, DOE modeled both helical and multi-pass condensing heat exchanger designs [38] and calculated a weighted average MPC based on manufacturer market shares. The intent of DOE's aforementioned statements in the May 2016 CWH ECS NOPR TSD was to explain why condensing gas-fired storage water heaters currently on the market typically have lower standby losses than do non-condensing storage water heaters. Rather than assuming that manufacturers would change their designs, DOE was simply interpreting the efficiency distributions of models currently on the market. DOE clarifies that the intended meaning of its statement was that condensing gas-fired storage water heaters (including those with helical and multi-pass condensing heat exchanger designs) typically have less surface area on flue pipes (*i.e.,* fewer pipes or smaller-diameter pipes) that vent vertically outside the top of the water heater and into the vent system than do non-condensing gas-fired storage water heaters, therefore providing less opportunity for standby heat loss. In other words, in non-condensing gas-fired storage water heaters, all flue pipes typically vent outside the water heater; therefore, all flue pipes provide a direct air path for standby flue losses out the top of the water heater. Conversely, condensing heat exchangers often include flue pipes (or a single helical pipe) that do not vent out to the top of the water heater and therefore do not provide a direct air path for flue losses (*e.g.,* in a multi-pass heat exchanger, flue gases in many tubes are re-routed within the heat exchanger rather than vented outside the water heater).

Additionally, DOE notes that it has identified at least one manufacturer who produces commercial gas-fired tankless water heaters that include a secondary, condensing heat exchanger made of an aluminum alloy and are intended for potable water heating applications. Therefore, DOE included the manufacturing costs of this model in its market-share weighted average MPCs for gas-fired tankless water heaters in the analyses for both the May 2016 CWH ECS NOPR and this NOPR. However, DOE did not identify any circulating water heaters or hot water supply boilers on the market that include an aluminum heat exchanger, and, therefore, DOE only included condensing heat exchangers made of stainless steel in its cost estimates for circulating water heaters and hot water supply boilers. Chapter 5 of the NOPR TSD includes further details on the materials and cost estimates for condensing heat exchangers.

In the analysis for the withdrawn May 2016 CWH ECS NOPR, DOE did not include the costs of ASME construction as part of the MPC. Bradford White disagreed with DOE's decision not to include the costs of ASME construction in cost estimates for commercial gas-fired storage water heaters, and argued that DOE should consider these costs in its analysis. Bradford White stated that while ASME construction is not required in most States for storage water heaters at DOE's representative capacity (*i.e.,* 100 gallons, 199,000 Btu/h), ASME construction is required for models with an input capacity exceeding the ASME criteria. According to the commenter, manufacturing costs would be higher for condensing products if ASME construction is required. Bradford White also pointed out that Kansas requires ASME construction for all storage water heaters with a storage volume exceeding 85 gallons. (Bradford White, No. 42 at p. 7)

In response to Bradford White's concerns, DOE adjusted its MPC estimates for commercial gas-fired storage water heaters for this NOPR to account for the costs of ASME construction. Specifically, DOE estimated that 20 percent of commercial gas-fired storage water heater shipments are manufactured with ASME construction, based on feedback from manufacturer interviews. For this share of the market, DOE applied a multiplier of 1.2 to the MPC to account for the various costs associated with ASME construction (*e.g.,* materials, labor, testing). This multiplier is consistent with feedback from manufacturer interviews and with the approach DOE used for estimating the costs of ASME construction for instantaneous water heaters and hot water supply boilers in the May 2016 CWH ECS NOPR engineering analysis. Chapter 5 of the NOPR TSD includes additional details on DOE's analysis of ASME construction for commercial gas-fired storage water heaters.

In the analysis for the withdrawn May 2016 CWH ECS NOPR, DOE estimated the burdened assembly and fabrication labor wages as $24/hour.[39] In response, Bradford White indicated that the average burdened assembly and fabrication labor wages used in DOE's analysis of $24/hour was significantly too low. Bradford White stated that this value is closer to the actual value (but still low) if DOE is only considering wages plus benefits. However, Bradford White argued that DOE should consider fully burdened wages (including wages, benefits, and overhead) in its cost estimates. Bradford White further stated that it provided similar feedback regarding the burdened wage during manufacturer interviews and was disappointed that this feedback was not incorporated in the May 2016 CWH ECS NOPR analysis. (Bradford White, No. 42 at p. 14)

In response, DOE's estimate of $24/hour for burdened assembly and fabrication labor wages is based on feedback from manufacturer interviews across many manufacturing industries. DOE typically uses the same wage estimate for many manufacturing industries because the wages across these industries are competitive (*e.g.,* welders are in demand in many manufacturing industries in addition to the CWH equipment industry). DOE also notes that other than Bradford White, no

[36] Page 3–21 of the May 2016 CWH ECS NOPR TSD is page 56 of the document PDF file.

[37] Page 5–21 of the May 2016 CWH ECS NOPR TSD is page 107 of the document PDF file.

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

[39] DOE uses the term ''burdened wage'' to refer to the gross wages and benefits paid to a manufacturing employee.

manufacturers of CWH equipment indicated that this labor wage estimate was too low in either public comments or manufacturer interviews. Additionally, DOE does not consider employee overhead costs in its labor wage estimates. While Bradford White's comment does not specify what is meant by ''overhead,'' DOE presumes that the costs to which Bradford White is referring to are those that DOE designates as ''non-production costs,'' such as general corporate costs or, alternatively, a ''shop rate.'' The DOE wage estimate reflects only gross wages and benefits to the employee. Other overhead costs are captured in the manufacturer markup that is applied to the manufacturer production cost to determine the manufacturer selling price. DOE does not believe that these costs would directly scale with increased labor requirements in the same manner as wages and benefits. However, in order to better represent the costs for Bradford White of manufacturing CWH equipment, DOE included a 20 percent higher value for burdened assembly and fabrication labor wages for a portion of the market in the development of MPC estimates in this NOPR.

7. Manufacturing Production Costs

After calculating the cost estimates for all the components in each torn-down unit, DOE totaled the cost of materials, labor, depreciation, and direct overhead used to manufacture each type of equipment in order to calculate the MPC. DOE used the results of the teardowns on a market-share weighted average basis to determine the industry average cost increase to move from one efficiency level to the next. DOE reports the MPCs in aggregated form to maintain confidentiality of sensitive component data. DOE obtained input from manufacturers during the manufacturer interview process on the MPC estimates and assumptions. Chapter 5 of the NOPR TSD contains additional details on how DOE developed the MPCs and related results.

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

DOE notes that it developed its MPC estimates based on teardowns of CWH equipment from a variety of manufacturers. DOE conducted several rounds of manufacturer interviews and follow-up interviews with all CWH equipment manufacturers that responded to DOE's requests for interviews. As part of the manufacturer interview process, DOE sought feedback on its MPC estimates, as well as feedback on specific component, material, labor, and assembly costs. DOE's methodology for developing MPC estimates involves estimating the material, labor, depreciation, and overhead costs for every part and assembly within a unit. This level of detail allows DOE to estimate the cost of units that were not physically torn down, or to estimate the costs of making slight design changes such as adding an inch of insulation or increasing heat exchanger size. DOE presented manufacturers with MPC estimates broken down by each assembly (*e.g.,* burner and gas valve, heat exchanger, controls) of the water heater, or even a BOM of a torn-down unit from that manufacturer for specific feedback on the estimated costs for every single part within the torn-down unit. As part of the manufacturer interview process, manufacturers did not provide any specific feedback on components or labor that would call into question the validity of the incremental MPC estimates for moving from non-condensing to condensing technology. The incremental MPC estimate reflects the additional components needed to build a condensing product while subtracting components that are either replaced or obviated. For example, condensing gas-fired storage water heaters require a mechanical draft combustion system, while baseline non-condensing models do not. Conversely, baseline non-condensing commercial water heaters typically include an electromechanical flue damper, while condensing models do not because they have a mechanical-draft combustion system that obviates the need for a flue damper.

Additionally, as discussed in section IV.C.6 of this NOPR, DOE standardized non-efficiency-related features across all efficiency levels. This may cause DOE's incremental MPC estimates to seem lower than that of equipment currently on the market, because in many cases condensing equipment is currently marketed as a premium product and includes features (*e.g.,* advanced controls, powered anode rods, modulating gas valves) that are not necessary for condensing operation and do not affect efficiency as measured by DOE's test procedure. Chapter 5 of the NOPR TSD includes further detail on the exclusion of costs for non-efficiency-related features from DOE's MPC estimates.

The MPC estimates presented in this NOPR and chapter 5 of the NOPR TSD are market-shared weighted average MPCs, which will not necessarily be representative for every design pathway used by every manufacturer (*i.e.,* they reflect the industry average cost). DOE research suggests that the absolute and incremental MPCs between baseline and condensing levels are higher for some manufacturers than others. Therefore, DOE included multiple design pathways that are used by a range of manufacturers and that represent the vast majority of models on the market in the market-share weighted average cost estimates, both in absolute as well as incremental terms.

Regarding MPC estimates for tankless water heaters, DOE notes that a significant difference between the incremental cost for condensing technology for gas-fired storage water heaters and gas-fired tankless water heaters is the cost of a blower. DOE research and manufacturer feedback suggest that commercial gas-fired tankless water heaters typically feature forced-draft combustion systems, necessitating a blower for both condensing as well as non-condensing models. Therefore, while reflected in the incremental MPC difference between non-condensing and condensing gas-fired storage water heaters, the cost of a blower would not be reflected in the incremental MPC difference for moving from non-condensing to condensing technology for gas-fired tankless water heaters.

Regarding the incremental costs between condensing levels, the additional heat exchanger area required in DOE's analysis to increase thermal efficiency between condensing levels is based upon feedback from manufacturer interviews. Multiple condensing units that DOE torn down had a rated thermal efficiency in the middle of the range of condensing thermal efficiency levels (*e.g.,* 95–96 percent). MPC estimates for lower condensing efficiency levels (*i.e.,* 90 and 92 percent) were developed by scaling down the design of more-efficient units by reducing the size of their condensing heat exchangers, while assuming other components generally do not change, as described in detail in chapter 5 of the NOPR TSD.

Finally, DOE notes that its analysis does not consider labor to be a fixed cost and instead determines the labor hours required for production separately for each efficiency level and each equipment category. Therefore, DOE's analysis takes into account the costs for any additional labor required for producing more efficient equipment.

For the reasons previously mentioned, DOE has tentatively concluded that its methodology for developing MPC estimates initially presented in the May 2016 CWH ECS NOPR is sound and has maintained the same methodology for this NOPR. In addition, as noted previously, this NOPR analysis includes results from 11 additional physical teardowns of water heaters and hot water supply boilers (in addition to the physical teardowns performed for the previous (withdrawn) NOPR analysis of models still available on the market), which replaced several of the virtual teardowns conducted for the previous NOPR analysis. These additional physical teardowns were performed to ensure that the MPC estimates better reflect designs of models on the market by including physical teardowns of models from additional manufacturers at numerous efficiency levels. Additionally, DOE revised inputs to the development of MPC estimates based on updated pricing information (for raw materials and purchased parts). These changes resulted in refined MPCs and production cost percentages. Table IV.16, Table IV.17, and Table IV.18 of this document show the MPC for each combination of thermal efficiency and standby loss levels for each equipment category.

TABLE IV.16—MANUFACTURER PRODUCTION COSTS FOR COMMERCIAL GAS-FIRED STORAGE WATER HEATERS, 100-GALLON RATED STORAGE VOLUME, 199,000 Btu/h INPUT CAPACITY

Thermal efficiency level	Thermal efficiency	MPC (2020$)
E_t EL0	80	$1,180.42
E_t EL1	82	1,200.45
E_t EL2	90	1,306.87
E_t EL3	92	1,317.83
E_t EL4	95	1,338.92
E_t EL5	99	1,377.83

TABLE IV.17—MANUFACTURER PRODUCTION COSTS FOR RESIDENTIAL-DUTY GAS-FIRED STORAGE WATER HEATERS, 75-GALLON RATED STORAGE VOLUME, 76,000 Btu/h INPUT CAPACITY

Efficiency level	UEF (high draw pattern) *	MPC (2020$)
EL0	$0.6597 - (0.0009 \times V_r)$	$318.64
EL1	$0.6797 - (0.0009 \times V_r)$	323.35
EL2	$0.7497 - (0.0009 \times V_r)$	411.16
EL3	$0.8397 - (0.0009 \times V_r)$	474.64
EL4	$0.9297 - (0.0009 \times V_r)$	645.18
EL5	$0.9997 - (0.0009 \times V_r)$	663.47

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

TABLE IV.18—MANUFACTURER PRODUCTION COSTS FOR GAS-FIRED INSTANTANEOUS WATER HEATERS AND HOT WATER SUPPLY BOILERS

Thermal efficiency level	Thermal efficiency (%)	MPC (2020$)	
		Gas-fired tankless water heaters	Gas-fired circulating water heaters and hot water supply boilers
		250,000 Btu/h	399,000 Btu/h
E_t EL0	80	$517.86	$1,006.19
E_t EL1	82	525.79	1,015.39
E_t EL2	84	533.55	1,097.04
E_t EL3	92	608.08	2,655.89
E_t EL4	94	624.08	2,811.34
E_t EL5	96	647.19	2,966.78

8. Manufacturer Markup and Manufacturer Selling Price

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

To calculate the MSP for CWH equipment, DOE multiplied the calculated MPC at each efficiency level by the manufacturer markup. See chapter 12 of the NOPR TSD for more details about the manufacturer markup calculation and the MSP calculations.

9. Shipping Costs

Manufacturers of CWH equipment typically pay for shipping to the first step in the distribution chain. Freight is not a manufacturing cost, but it is a substantial cost incurred by the manufacturer that is passed through to

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

consumers. Therefore, DOE accounted for shipping costs of CWH equipment separately from other non-production costs.

In the May 2016 CWH ECS NOPR, shipping costs for all classes of CWH equipment were determined based on the area of floor space occupied by the unit. In response, Bradford White stated that while consumer water heaters are mostly shipped in semi-trailers, it is more common for commercial water heaters to be shipped via less than truckload (''LTL''), when either lower quantities are being shipped, potentially in an emergency situation, or when a semi-trailer is not going to the area to which the commercial water heater is being delivered. Bradford White stated that DOE's analysis should be weighted more to LTL shipping, which is based on weight. Per Bradford White, condensing water heaters are heavier than non-condensing models and hence would cost more to ship on an LTL basis. Bradford White also commented that commercial and residential-duty storage water heaters are typically shipped with consumer water heaters for distributors stocking inventory, rather than being segregated. (Bradford White, No. 42 at p. 12) Bradford White also disagreed with DOE's statement in the May 2016 CWH ECS NOPR that an increase of height of storage water heaters would not affect shipping costs because commercial storage water heaters cannot be double-stacked. Bradford White argued that when commercial storage water heaters are shipped via semi-trailers, it is very common for the space above them to be used for smaller products. (Bradford White, No. 42 at pp. 12–13)

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

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

D. Markups Analysis

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

DOE developed baseline and incremental markups for each actor in the distribution chain. DOE developed supply chain markups in the form of multipliers that represent increases above equipment purchase costs for key market participants, including CWH equipment wholesalers/distributors, retailers, and mechanical contractors and general contractors working on behalf of commercial consumers. Baseline markups are applied to the price of products with baseline efficiency, while incremental markups are applied to the difference in price between baseline and higher-efficiency models (the incremental cost increase). The incremental markup is typically less than the baseline markup and is designed to maintain similar per-unit operating profit before and after amended standards.[41]

1. Distribution Channels

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

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

- Manufacturer → Wholesaler → Mechanical Contractor → Consumer
- Manufacturer → Manufacturer Representative → Mechanical Contractor → Consumer
- Manufacturer → Retailer → Mechanical Contractor → Consumer

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

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

[41] Because the projected price of standards-compliant products is typically higher than the price of baseline products, using the same markup for the incremental cost and the baseline cost would result in higher per-unit operating profit. While such an outcome is possible, DOE maintains that in markets that are reasonably competitive it is unlikely that standards would lead to a sustainable increase in profitability in the long run.

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

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

- Manufacturer → Consumer
- Manufacturer → Retailer → Consumer

2. Comments on Withdrawn May 2016 CWH ECS NOPR

In response to the withdrawn NOPR, Rheem challenged DOE's use of the 2005 the Air Conditioning Contractors of America (''ACCA'') financial analysis in the development of markups on the basis that it is outdated. (Rheem, No. 43 at p. 21) DOE develops its mechanical contractor markups using the most current data available. For this NOPR, DOE updated from the 2012 Economic Census to use data from the 2017 Economic Census. However, the 2017 Economic Census does not separate the mechanical contractor segment into replacement and new construction markets. To calculate markups for these two markets for the withdrawn NOPR, DOE utilized the 2005 ACCA financial data, which reported gross margin data for the entire mechanical contractor market, as well as for both the replacement and new construction markets. For this NOPR, DOE used more current data from the 2020 ACCA Cool Insights document. Using these data, DOE calculated that the baseline markups for the replacement and new construction markets are 1.7 and 15.5 percent lower, respectively, than for all mechanical contractors serving all markets. The markup deviations were applied to the baseline and incremental markups developed from the 2017 Economic Census data.

In the withdrawn NOPR, DOE sought comments on the percentages of shipments allocated to the distribution channels relevant to each equipment class. 81 FR 34440, 34479 (May 31, 2016). In response, three manufacturers commented that wholesalers and manufacturer's representatives were underrepresented in DOE's channel shares, whereas retailers were overrepresented. (A.O. Smith, No. 39 at pp. 11–12; Bradford White, No. 42 at p. 8; Lochinvar, Public Meeting Transcript, No. 20 at p. 52) In addition, Rheem commented that it was reiterating its response to the October 2014 RFI regarding the percentage of shipments allocated to distribution channels. (Rheem, No. 43 at p. 21) In this response, Rheem stated that the majority of shipments are distributed through the wholesale channel. (Rheem, No. 10, at p. 4)

Based on these comments and DOE's additional research, DOE has decreased the percentage of shipments allocated to retail distribution channels and increased the percentage of shipments allocated to wholesaler and manufacturer's representative channels in the markups analysis. For circulating water heater and hot water supply boiler equipment, the percentage of shipments allocated to retailers was decreased from 5 percent to zero, whereas the allocation to wholesalers was increased from 70 percent to 75 percent. For commercial gas-fired storage water heater equipment, the percentage of shipments allocated to retailers was decreased from 15 percent to 5 percent in the new construction market and from 20 percent to 5 percent in the replacement market, whereas the allocation to wholesalers was increased from 80 percent to 90 percent in the new construction market and from 75 percent to 90 percent in the replacement market. For the residential-duty gas-fired storage water heater equipment class, the percentage of shipments allocated to retailers was decreased from 20 percent to 10 percent in the new construction market, from 25 percent to 15 percent in the replacement market for the commercial sector, and from 30 percent to 15 percent in the replacement market for the residential sector. The percentage of shipments allocated to wholesalers was increased from 75 percent to 85 percent in the new construction market, from 70 percent to 80 percent in the replacement market for the commercial sector, and from 67.5 percent to 80 percent in the replacement market for the residential sector. In addition, the percentage of shipments allocated to national accounts was increased from 2.5 percent to 5 percent. These adjustments address the overall assertion of the commenters and that the resulting channel shares reflect the market distribution, although A.O. Smith called for even greater reductions in shipments allocated to retail distribution channels. Appendix 6A of the NOPR TSD provides detail on the percentage of shipments allocated to each distribution channel by equipment category.

During the public meeting for the withdrawn NOPR, Raypak commented that manufacturer's representatives do not markup equipment in the same way as wholesalers, since manufacturer's representatives make sales based on the expertise they provide to consumers. (Raypak, Public Meeting Transcript, No. 20 at p. 53–56) NEEA stated during the public meeting that the expertise of manufacturer's representatives is utilized more in the replacement market, and in this market, a consumer receives an equipment price quote from a manufacturer's representative and then will shop the equipment price to other competitors in the market, such as wholesalers. This forces manufacturer's representatives to maintain competitive markups with wholesalers. (NEEA, Public Meeting Transcript, No. 20 at p. 55) DOE appreciates Raypak and NEEA's comments on this issue and plans to continue researching manufacturer's representative markups. Neither Raypak nor NEEA provided information or data to update the estimated manufacturer's representative markups. Since DOE does not have enough information at this point to estimate separate markups for manufacturer's representatives, DOE assumes that the manufacturer's representative markup is the same as the wholesaler markup.

3. Markups Used in This NOPR

To develop markups for this NOPR, DOE utilized several sources, including the following: (1) The Heating, Air-Conditioning & Refrigeration Distributors International (''HARDI'') 2013 Profit Report[42] to develop wholesaler markups; (2) the 2020 ACCA Cool Insights document containing financial analysis for the heating, ventilation, air-conditioning, and refrigeration (''HVACR'') contracting industry[43] to develop mechanical contractor markups; (3) the U.S. Census Bureau's 2017 Economic Census data[44] for the commercial and institutional building construction industry to develop mechanical and general contractor markups; and (4) the U.S. Census Bureau's 2017 Annual Retail

[42] Heating Air-conditioning & Refrigeration Distributors International. *Heating, Air-Conditioning & Refrigeration Distributors International 2013 Profit Report.*

[43] Air Conditioning Contractors of America (ACCA). *Cool Insights 2020: ACCA's Contractor Financial & Operating Performance Report (Based on 2018 Operations).* 2020.

[44] U.S. Census Bureau. 2017 Economic Census Data. 2020. Available at *www.census.gov/programs-surveys/economic-census.html.*

Trade Survey[45] data to develop retail markups.

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

E. Energy Use Analysis

The purpose of the energy use analysis is to assess the energy requirements (*i.e.,* annual energy consumption) of CWH equipment described in the engineering analysis for a representative sample of building types that utilize the equipment, and to assess the energy-savings potential of increased equipment efficiencies. DOE uses the annual energy consumption in the LCC and PBP analysis to establish the operating cost savings at various equipment efficiency levels.[47] DOE estimated the annual energy consumption of CWH equipment at specified energy efficiency levels across a range of commercial and multifamily residential buildings in different climate zones, with different building characteristics, and including different water heating applications. The annual energy consumption includes use of natural gas (or liquefied petroleum gas (''LPG'')) as well as use of electricity for auxiliary components.

In the October 2014 RFI, DOE indicated that it would estimate the annual energy consumption of CWH equipment at specified energy efficiency levels across a range of applications, building types, and climate zones. 79 FR 62899, 62906–62907 (Oct. 21, 2014). DOE developed representative hot water volumetric loads and water heating energy usage for the selected representative products for each equipment category and building type combination analyzed. This approach captures the variability in CWH equipment use due to factors such as building activity, schedule, occupancy, tank losses, and distribution system piping losses.

For commercial building types, DOE used the daily load schedules and normalized peaks from the 2013 DOE Commercial Prototype Building Models[48] to develop gallons-per-day hot water loads for the analyzed commercial building types.[49] DOE assigned these hot water loads on a square-foot basis to associated commercial building records in the EIA's 2012 CBECS[50] in accordance with their principal building activity subcategories. For residential building types, DOE used the hot water loads model developed by Lawrence Berkeley National Laboratory (''LBNL'') for the 2010 rulemaking for ''Energy Conservation Standards for Residential Water Heaters, Direct Heating Equipment, and Pool Heaters.''[51] DOE applied this model to the residential building records in the EIA's 2009 Residential Energy Consumption Survey (''RECS'').[52] [53] For RECS housing records in multi-family buildings, DOE focused only on apartment units that share water heaters with other units in the building. Since the LBNL model was developed to analyze individual apartment hot water loads, DOE had to modify it for the analysis of whole building loads. DOE established statistical average occupancy of RECS apartment unit records when determining the individual apartment unit's load. DOE also developed individual apartment loads as if each were equipped with a storage water heater in accordance with LBNL's methodology. Then, DOE multiplied the apartment unit's load by the number of representative units in the building to determine the building's total hot water load.

DOE converted daily volumetric hot water loads into daily Btu energy loads by using an equation that multiplies a building's gallons-per-day consumption of hot water by the density of water,[54] specific heat of water,[55] and the hot water temperature rise. To calculate temperature rise, DOE developed monthly dry bulb temperature estimates for each U.S. State using typical mean year (''TMY'') temperature data as captured in location files provided for use with the DOE EnergyPlus Energy Simulation Software.[56] Then, these dry bulb temperatures were used to develop inlet water temperatures using an equation and methodology developed by the National Renewable Energy Laboratory (''NREL'').[57] DOE took the difference between the building's water heater set point temperature and inlet temperature to determine temperature rise (see chapter 7 of the NOPR TSD for more details). In addition, DOE developed building-specific Btu load adders to account for the heat losses of building types that typically use recirculation loops to distribute hot water to end uses. DOE converted daily hot water building loads (calculated for each month using monthly inlet water temperatures) to annual water heater Btu loads for use in determining annual energy use of water heaters at each efficiency level.

DOE developed a maximum hot water loads methodology for buildings for determining the number of representative equipment needed using the data and calculations from a major water heater manufacturer's sizing calculator.[58] DOE notes that the sizing calculator used was generally more comprehensive and transparent in its maximum hot water load calculations than other publicly-available sizing calculators identified. This methodology was applied to commercial building records in 2012 CBECS and residential building records in 2009 RECS to

[45] U.S. Census Bureau. 2017 Annual Retail Trade Survey. 2019. Available at *www.census.gov/retail/.*

[46] *The Sales Tax Clearing House.* 2021. Available at *www.thestc.com/STrates.stm.* Last accessed March 21, 2021.

[47] In this case, these efficiency levels comprise combinations of thermal efficiency and standby mode performance.

[48] U.S. Department of Energy—Office of Energy Efficiency and Renewable Energy. *Commercial Prototype Building Models.* 2013. Available at *www.energycodes.gov/commercial-prototype-building-models.*

[49] Such commercial building types included the following: Small office, medium office, large office, stand-alone retail, strip mall, primary school, secondary school, outpatient healthcare, hospital, small hotel, large hotel, warehouse, quick service restaurant, and full service restaurant.

[50] U.S. Energy Information Administration (EIA). *2012 Commercial Building Energy Consumption Survey (CBECS) Data.* 2012. Available at *www.eia.gov/consumption/commercial/data/2012/.*

[51] U.S. Department of Energy—Office of Energy Efficiency and Renewable Energy. *Final Rule Technical Support Document: Energy Conservation Standards for Residential Water Heaters, Direct Heating Equipment, and Pool Heaters.* April 8, 2010. EERE–2006–STD–0129–0149. Available at *www.regulations.gov/#!documentDetail;D=EERE-2006-STD-0129-0149.*

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

[53] DOE is aware that a new version of CBECS will likely be available for the next rulemaking phase, and DOE will evaluate its applicability for the commercial water heater energy analysis in that phase. As discussed in section IV.F, the 2009 RECS contained information specific to multifamily buildings that was not available in the 2015 RECS analysis. EIA plans to release the characteristics data for the 2020 RECS in late 2021, and DOE will also evaluate its applicability for the commercial water heater energy analysis in the next rulemaking phase.

[54] DOE used 8.29 gallons per pound.

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

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

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

[58] A.O. Smith. *Pro-Size Water Heater Sizing Program.* Available at *www.hotwatersizing.com/.* Last accessed in March 2015.

determine their maximum gallons-per-hour requirements, assuming a temperature rise specific to the building. DOE divided these maximum building loads by the first-hour capability of the baseline representative model of each equipment category to determine the number of representative water heater units required to service the maximum load, but for buildings with maximum load durations of 2 or 3 hours, DOE divided maximum loads by the 2- or 3-hour delivery capability of the baseline representative model. For each equipment category, DOE sampled CBECS and RECS building loads in need of at least 0.9 water heaters, based on the representative model analyzed, to fulfill their maximum load requirements. Due to the maximum input capacity and storage specifications of residential-duty commercial gas-fired storage water heaters, DOE limited the buildings sample of this equipment class to building records requiring four or fewer representative water heaters to fulfill maximum load since larger maximum load requirements are more likely served by larger capacity equipment. For gas-fired tankless water heaters, an adjustment factor was applied to the first-hour capability to account for the shorter time duration for sizing this equipment, given its minimal stored water volume. DOE used the Modified Hunter's Curve method[59] for sizing of gas-fired instantaneous water heaters to develop the adjustment factors for tankless water heaters. Gas-fired circulating water heaters and hot water supply boilers were teamed with unfired storage tanks to determine their first-hour capabilities since this is the predominant installation approach for this equipment.

To the extent that there are concerns that the annual energy use for commercial gas instantaneous tankless water heaters is significantly lower than commercial gas-fired storage water heaters even where thermal efficiency input rates are similar, DOE notes that the applied adjustment factor modifies the first hour delivery capability calculations of commercial gas-fired tankless water heaters to account for the shorter time duration used to size for a very short ''instantaneous'' peak for this equipment, given the minimal volume of stored water to buffer meeting short duration peaks during the one hour maximum load period used for the first hour rating. DOE used the Modified Hunter's Curve method to develop the adjustment factors, or divisors, based on residential or commercial building type (as shown in appendix 7B of the NOPR TSD). These adjustment factors adapt the sizing methodology for water heaters with storage to a methodology suitable for sizing water heaters or water heating systems without storage. The result of this adjustment is that the tankless water heater representative model, relative to the commercial gas-fired storage water heater representative model with a similar input rate, is sized to meet a significantly smaller overall maximum hot water load. This results in the lower annual energy use across all efficiency levels, since for a given end use or building, the smaller maximum load being serviced per unit also proportionally correlates with the lower average daily loads serviced by the tankless water heater.

Given the hot water load requirements as well as the equipment needs of the sampled buildings, DOE was able to calculate the hours of operation to serve hot water loads and the hours of standby mode for the representative model of each equipment category to service each sampled building. Since the number of water heaters allocated to a specific building was held constant at the baseline efficiency level, a water heater's hours of operation decreased as its thermal efficiency improved. This decrease in operation, in combination with standby loss performance, led to the energy savings achieved at each efficiency level above the baseline. For commercial gas-fired storage water heaters, DOE used the standby loss levels identified in the engineering analysis to estimate energy savings from more-stringent standby loss levels. For residential-duty gas-fired storage water heaters, DOE estimated standby loss levels for each UEF level developed in the Engineering Analysis. To estimate standby loss levels DOE first estimated recovery efficiency. DOE developed a regression between the measured recovery efficiency and the increase in UEF over the minimum UEF specified by current standards for equipment in DOE's CCMS database. Recovery efficiency was assumed to be equivalent to thermal efficiency, and the regression results were in turn used to translate UEF at different analyzed efficiency levels analyzed to thermal efficiency. DOE used the Water Heater Analysis Model (''WHAM'') equation as modified for the daily energy consumption in the current UEF test procedure (based on the high usage draw profile), the analyzed UEF from the engineering analysis, and the regression based recovery efficiency to calculate the standby energy loss (Btu/hr °F) at each UEF efficiency level. This conversion is discussed in Chapter 7 of the NOPR TSD. Section IV.C.4 of this NOPR and chapter 5 of the NOPR TSD include additional details on the thermal efficiency, standby loss, and UEF levels identified in the engineering analysis.

For this NOPR, DOE also further consulted ASHRAE[60] and Electric Power Research Institute (''EPRI'')[61] handbooks. These resources contain data on distribution losses and maximum load requirements of different building types and applications, which were used to compare and corroborate analyses of the average and peak loads derived from the CBECS and RECS data.

To be clear, while DOE described calculations above relating to the number of units required to meet a building load, the LCC analysis calculates results for individual pieces of equipment. The energy usage analyses discussed in this section of this NOPR provide key inputs to the LCC analysis, namely monthly and annual energy consumption at each efficiency level for each sampled building as well as the hours of burner operation at rated input rate and the hours in standby mode per unit for water heaters to examine relative energy savings from thermal efficiency and standby loss changes. The energy analysis also helps DOE identify buildings for which each specific water heater might be suited (*i.e.,* if the building load is too low to require 0.9 units of a defined representative unit or so large the building requires more than 4 residential duty units, DOE excludes that building from sampling for that equipment).

DOE received multiple comments on its energy use analysis presented in the withdrawn 2016 NOPR. There was discussion of the need or lack thereof of incorporating backup or redundant water heaters into the energy and life cycle cost analysis as well as a concern that manufacturing engineering guidelines tend to oversize equipment.

DOE agrees that manufacturing engineering guidelines are likely to result in oversizing hot water equipment in many applications, and that the level

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

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

[61] Electric Power Research Institute (EPRI). *Commercial Water Heating Applications Handbook.* 1992. Electric Power Research Institute: Palo Alto, CA. Report No. TR–100212. Available at *www.epri.com/abstracts/Pages/ProductAbstract.aspx?ProductId=TR–100212.*

of built-in oversizing using such guidelines in this regard likely also results in the LCC analysis providing conservative estimates of economic benefits than might otherwise be the case. DOE did not include redundant units in the LCC analysis. Although redundant units may exist in certain buildings, DOE was not able to identify any information or data on this topic, nor have commenters in the course of this rulemaking provided information or detail as to the type of water heater plants where installation of a redundant unit would be considered common practice; therefore, DOE assumed that fully redundant units would be the exception in most installations. DOE considered how such a unit would be integrated into a system, but it is not clear if a redundant unit is piped into the system and actively part of the operating service hot water system (such that a hot water ''plant'' serving the building is further oversized from sizing guidelines), or if it is purchased and not utilized, in the latter case effectively a pre-purchase available for a subsequent installation or use. DOE also notes that increases in efficiency increase the overall hot water delivery capacity for similar input capacity water heaters in either single- or multiple-service water heater unit ''plants'' in a building. DOE's analysis has not considered increased purchase costs for fully redundant units when they may occur, however it has also not included the potential cost savings for downsizing the input rating of the water heaters that would be needed to service a building's known hot water load and any subsequent benefit from downsizing of a venting system, providing in this regard a conservative assessment of the costs to install the water heating system. DOE also considered that incorporation of redundant units, which might be expected to exist at all efficiency levels anyway, would add unnecessary complication given the lack of available information on how likely and in what building types a redundant unit would be purchased and whether such a unit is piped into the domestic water system and utilized directly or simply pre-purchased, to be installed at a later date for immediate replacement when necessary. In the latter case, the earlier purchase does not affect the eventual life of the equipment or additional installation costs not already captured. Given that DOE's current analysis does not reflect the benefits of downsizing that would occur for all CWH consumers, and its understanding that manufacturer sizing guidelines may already allow for CWH systems to be conservatively sized, incorporation of redundant units would be overly conservative in establishing the first-cost impact to the average consumer.

To the extent that parties may be concerned that DOE's commercial packaged boiler analysis also included commercial water heating loads in some portion of buildings that uses space heating boilers to meet both space and service water heating loads and that DOE is double counting those loads, DOE clarifies that its analysis does not double count the national energy savings from service hot water loads included in the commercial packaged boiler final rule in this CWH equipment NOPR. The CBECS and RECS data are used in the CWH equipment analysis to develop a representative hot water load profile (*i.e.,* how much hot water is supplied to the buildings), which in turn is used to develop estimates of the operating hours and energy use for representative CWH equipment when they are installed. This is distinct from the shipments data, which are used to determine the number of units introduced into the market. However, the shipments data do not specify the type of building in which the equipment is actually installed, and such data are not available. The energy use analysis provides an estimate of how the shipped equipment is distributed across the various applications and the associated operating hours. The boiler loads in the commercial packaged boiler analysis included an assumption that some buildings use space heating boilers to provide for service hot water, however that assumption was used to develop representative loads for the boiler equipment where space heating boilers were used in place of commercial water heaters (*i.e.,* in accounting for the hot water load of buildings that use the same fuel for water and space heating in the overall energy use analysis, 20 percent of those boiler installations were assumed to use a commercial packaged boiler for both space and water heating based on other reviewed data). The boiler representative energy consumption numbers were drawn from CBECS and RECS data and are separately applied to the shipments of commercial space heating boiler. 85 FR 1592 (January 10, 2020) The CWH analysis, which did not rely directly on hot water load estimates from CBECS, did not separately make such an allowance since it would simply have reduced the building count without impacting the hot water load profiles used in the CWH analysis.

In this NOPR, the energy use analysis develops a typical energy usage for installations of the representative CWH equipment in buildings that are appropriate for using this equipment but relies on characteristics data rather than CBECS or RECS estimates for water heating energy consumption in the buildings. The shipments analysis is separate from the energy use analysis and uses AHRI CWH equipment shipment data where available. DOE applies the CWH energy use analysis to the shipments analysis to calculate the national energy savings achieved by this NOPR. Thus, the shipment analysis for the CWH rule does not rely on CBECs and RECs energy estimates directly, so the national energy impact is not affected if, in fact, a particular building may have served its domestic water heating load with a boiler in place of a water heater.

Because DOE models a diverse set of buildings with differing loads and usage schedules, following is additional information explaining how the statistical analysis results in a single estimated average energy usage for CWH equipment. DOE conducted its energy use analysis using a Monte Carlo approach, selecting from thousands of commercial building records in 2012 CBECS and thousands of residential housing records from 2009 RECS, including the impact of the building weight from CBECS and RECS, for those buildings that are appropriate uses of CWH equipment. Based on the characteristics data provided in each CBECS and RECS record, DOE determined maximum hot water loads for sizing equipment and daily hot water loads to determine equipment operation. Energy use was based on the equipment operation to meet the daily hot water loads, including recirculation loop losses for buildings which typically have this system design. The Monte Carlo approach (using the Crystal Ball Excel add-in) develops a distribution of inputs, as well as distributions of energy and energy savings as results which provides for calculating a statistical, weighted average of key model outputs, including average energy use, for all CWH equipment categories at each efficiency level. The calculated average CWH equipment utilization rates in terms of operating hours to meet the hot water loads are provided for each equipment type and efficiency level, which are available in appendix 7B of the NOPR TSD. Appendix 7B of the NOPR TSD also provides a table of building types that DOE assumed to use recirculation loops, as well as the operation hours of the recirculation loops. DOE estimates that commercial building records assigned recirculation loops comprised

29 percent of sampled commercial buildings from CBECS 2012. In addition, residential building records assigned recirculation loops comprised 68 percent of sampled residential buildings from RECS 2009. However, DOE notes that the economics for each individual commercial consumer modeled in the LCC are based on the energy usage attributed to that consumer, and do not rely on the statistical weighted-average energy use or utilization rates. Additional detail about the energy use analysis methodology is explained in detail in chapter 7 of the NOPR TSD. Additional detail about the LCC analysis is explained in detail in chapter 8 of the NOPR TSD.

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

To the extent that commenters may be concerned whether the analysis fairly represents individual water heater operation for water heaters in buildings in which multiple representative model units operate to meet the building's load, DOE notes that this would be system and building specific and its analysis may not capture the extremes of hot water loading on an individual water in all applications but would capture the average hot water loads on the equipment in those building. DOE notes that its analysis examines maximum sizing hot water loads and average daily hot water loads of 17 commercial building applications and 4 residential building applications, with additional variability in terms of specific end uses where identified in the CBECS or RECS data including variability based on inputs such as occupants, water fixtures, clothes washers, dishwashers, and food service as well as water mains inlet and outlet temperatures for estimating hot water loads. It also includes estimates of piping losses in circulating systems. Chapter 7 and appendix 7B in the NOPR TSD describe the calculation of hot water loads in the building. Appendix 7B also provides a table of building types that DOE assumed to use recirculation loops, as well as the operation hours of the recirculation loops. DOE estimates that commercial building records assigned recirculation loops comprised 29 percent of sampled commercial buildings from CBECS 2012. In addition, residential building records assigned recirculation loops comprised 68 percent of sampled residential buildings from RECS 2009.

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

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

In addition, DOE assumed the circulating water heater equipment class is equipped with a storage tank since this is the predominant installation configuration for this equipment. For this equipment class and representative input capacity, the analysis used a variable storage tank size of 250 to 350 gallons in volume, based on a triangle distribution consistent with manufacturer literature guidance as to typical storage tanks for the representative equipment input rating. However, DOE recognizes that for this equipment class as well, further variation in the storage tank sized with the equipment might also occur based on each individual building owner's preferences. DOE received no comment on its sizing of storage tanks in conjunction with circulating water heaters and boilers. DOE therefore retained this use of representative installation practices for the NOPR analysis. Chapter 7 of the NOPR TSD provides more information on the hot water delivery calculations for circulating water heaters.

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

DOE utilized the Modified Hunter's Curve approach for developing hot water delivery adjustment factors, or divisors, to adapt the sizing methodology for water heaters with storage to a methodology suitable for sizing water heaters without storage. DOE used the PVI Industries ''Water Heater Sizing Guide for Engineers'' which implements the Modified Hunter's Curve approach to develop the adjustment factors for sizing tankless water heaters. This guide provided a clear and thorough methodology for how to apply the Modified Hunter's curve to determine tankless water heater sizing. DOE's research indicates that mechanical contractors and design engineers commonly rely on this general sizing methodology for determining appropriately-sized equipment to install in commercial and residential buildings, and the PVI tool captures the need and general industry methodology required to size tankless water heating equipment to address short-duration loads peaks. In addition, DOE consulted the *ASHRAE Handbook of HVAC Applications,*[62] which provides guidance for sizing tankless and instantaneous water heaters. While the ASHRAE guidance also illustrates the Modified Hunter's Curve methodology, it was not as clear in application as the guidance provided by PVI tool. In this area of CWH equipment selection, DOE research indicates that manufacturer sizing tools are more commonly used than ASHRAE handbooks. Because of the lack of storage and the need to meet instantaneous building loads at sub-hour intervals, the sizing strategy for instantaneous water heaters results in a lower hot water service and lower energy consumption per unit of input capacity than is the case for either storage water heaters, or equipment like circulating water heaters and boilers where separate storage tanks are typically used. DOE received comment on the withdrawn 2016 NOPR noting that there were applications that used set point temperatures greater than the 140 °F high temperature used in that analysis, including specifically certain food service and restaurant applications. (AHRI, Public Meeting Transcript, No. 20 at p. 69; Raypak, No. 41 at pp. 3–4) It was also noted that in these higher water temperature applications, condensing technology performs less efficiently for any stainless steel heat exchanger. (Raypak, No. 41 at pp. 3–4) For this NOPR, DOE reviewed the set point temperatures in the 2013 DOE commercial prototype building models and determined that the hospital and nursing home set point temperatures should be 140 °F. These building applications would need set point temperatures greater than 120 °F to prevent outbreaks of Legionella, and they would have mixing valves installed to prevent scalding.

While DOE agrees that often food service and restaurant applications often have end uses requiring set point temperatures greater than 140 °F, these applications commonly use booster water heaters to increase hot water temperature for specific uses. Thus, DOE did not change the set point temperature universally for these applications in its analysis. The 2012 CBECS building record data included a data field for certain building applications, notably food service, that indicated whether the building used a booster water heater. Given this data field, DOE updated its analysis for the fast food restaurant, full-service restaurant/cafeteria, and bar/pub/lounge building applications. If these building records contained one or more booster water heaters, DOE assigned a set point temperature of 140 °F for determining maximum and average daily hot water loads. In these instances, DOE assumed the booster water heater would receive hot water from the main water heater and increase the temperature to 180 °F for purposes of dishwashing. If the CBECS building record did not contain a booster water heater, DOE assigned a set point temperature of 150 °F for determining maximum hot water loads. The set point temperature of 150 °F is a weighted average based on shipment data of low-temperature and high-temperature commercial dishwashers.[63] DOE assumed a food service building application that does not have a booster water heater uses either a low-temperature or high-temperature commercial dishwasher to clean dishes. Low-temperature commercial dishwashers typically call for an inlet water temperature of around 140 °F,[64] whereas high-temperature commercial dishwashers call for an inlet water temperature of 180 °F. This set point temperature assignment for food service building applications addresses higher delivery temperature in that market.

DOE reviewed data submitted on the withdrawn 2016 NOPR in Raypak comment to support its assertion that a set point temperature of 160 °F decreases the efficiency of condensing equipment. These data refer to decreases in condensing equipment efficiency; however, DOE's review of the data found that the decreased efficiency shown is likely primarily the result of the increased inlet water temperature referenced in the literature, not the increased set point or delivery temperature. Thus, DOE did not use the referenced data to adjust the thermal efficiency in the NOPR analysis.

To clarify how DOE developed the inlet water temperature, DOE conducted its energy use analysis using a Monte Carlo approach, selecting commercial building records from 2012 CBECS and residential building records from 2009 RECS in the development of maximum and daily hot water loads. Daily hot water loads were converted to energy use based on the equipment operation necessary to meet the load. Each

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

[63] Koeller and Company, and H.W. Hoffman & Associates. *A Report on Potential Best Management Practices—Commercial Dishwashers.* June 2010. Prepared for The California Urban Water Conservation Council. Available at *p2infohouse.org/ref/53/52002.pdf.* Last accessed May 1, 2020.

[64] Lim, E. Low-Temp Dish Machine Water Temperature. March 21, 2016. On Cleaner Solutions website. Available at *cleanersolutions.net/low-temp-dish-machine-water-temperature/.* Last accessed: November 2016.

building record's location is associated with a U.S. State. Using this State location, DOE assigned an average monthly inlet temperature for the CBECS Census Division or RECS Reportable Domain that the building resided in using monthly dry bulb temperature estimates for each State based on the TMY temperature data as captured in location files provided for use with the DOE EnergyPlus energy simulation software,[65] along with an equation and methodology developed by NREL.[66] DOE then summed the daily hot water loads of each month to determine the monthly hot water loads. DOE then summed the monthly hot water loads to determine annual hot water loads. The relationship between inlet temperature and energy use is for a given hot water usage, as inlet temperature is colder, energy use increases, since the water heater impart more heat to bring the inlet temperature to the set point temperature. Chapter 7 of the NOPR TSD provides detailed information on how energy use was calculated using inlet water temperature.

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

DOE notes that there is limited actual data on commercial hot water usage in the field. To the extent that stakeholders feel that DOE's analysis may under or overstate hot water usage, DOE notes that the analysis reflects both variation in direct hot water loads, inlet and outlet temperatures and piping/recirculation losses with a referenced estimating procedure. In the latter case, DOE assigned insulated supply, return, and riser recirculation loop piping to sampled buildings with a year of construction of 1970 or later. For buildings constructed prior to 1970, DOE assigned uninsulated supply piping to 25 percent of sampled buildings and uninsulated return piping to 25 percent of sampled buildings. DOE acknowledges that its energy use analysis may not account for the extent of all possible heat losses that occur in the field. These losses can result from poor control of circulating system flow, uninsulated or poorly insulated piping, leaks or other higher than expected tap flows, and poor water heater performance due to aging. These issues may result in higher hot water energy use than predicted by DOE's models. Due to the lack of field data on the magnitude of these energy losses across building applications, vintage, and location, DOE did not further attempt to include them into its analysis. While DOE recognizes that additional energy losses can occur in the field, to the extent that these losses occur, it suggests that the results of DOE's energy use analysis are conservative. In the withdrawn 2016 NOPR analysis, DOE received comment that the United States has reduced hot water use through DOE appliance and commercial equipment standards, as well as the ENERGY STAR program. (EEI, Public Meeting Transcript, No. 20 at p. 118; AHRI, Public Meeting Transcript. No. 20 at pp. 117–118) In this NOPR, DOE used schedules and loads from ASHRAE prototype models with augmented data reflecting recent standards affecting water heater used by commercial appliances and equipment. Specifically, DOE developed commercial building hot water loads using the daily schedules and square footage from the scorecards of the 2013 DOE commercial prototype building models and corresponding normalized peak water heater loads from the DOE EnergyPlus energy simulation input decks for these prototypes, both of which were vetted by the ASHRAE 90.1 Committee. DOE developed residential building hot water loads using the hot water loads model created by the LBNL for the 2010 final rule for Energy Conservation Standards for Residential Water Heaters, Direct Heating Equipment, and Pool Heaters. 75 FR 20112 (April 16, 2010). These data sources reflect expected hot water use at the time of their publication, including reductions of typical hot water use for certain appliances and commercial equipment based upon amended Federal standards and certain voluntary programs where those appliances are identified as part of the end use. DOE notes that its analysis and any eventual CWH standards are dominated by existing buildings and influenced by a lesser extent by shipments to new construction. Furthermore, DOE notes that to the extent that regulatory standards have or will reduce water loads, manufacturer sizing tools (as used in DOE's analysis for sizing water heaters in different applications) should also reflect the reduction in water usage for sizing purposes, thereby minimizing the impact of reduced hot water loads resulting from DOE regulation on the overall economic evaluation of higher standards.

With regards to the use of CWH equipment in residential buildings, DOE clarifies here that the only residential building type excluded from the analysis of CWH equipment was manufactured housing, since DOE determined that manufactured housing is not suitable for CWH equipment installation or use. Otherwise, for all other residential and commercial building types, if the estimated maximum sizing load of a sampled building was not at least 90 percent of the hot water delivery capability of the baseline representative model for any analyzed equipment category, then the building was not sampled since the building's maximum load is deemed not large enough to warrant the installation of the specific CWH equipment to service the load. When a residential building does not have a maximum sizing load that is large enough to justify the type of commercial water heater being analyzed, DOE assumes the residential building will use residential water heating equipment to service its load. In such a case, DOE did not sample the building in its energy use analysis. In particular, residential-duty gas-fired storage water heaters were modeled for energy use using a sample of 494 applicable CBECS records and 471 applicable RECS records. Single-family homes represented a small percentage of building records in the weighted Monte Carlo results of the energy use analysis. Multifamily 2–4 unit and 5+ unit apartment buildings were the primary building applications sampled in the residential sector. While the input rating for the representative residential-duty gas-fired storage water heaters is at the bottom of the range for that equipment, these units are still capable of delivering a significant amount of hot water. Based on the residential hot water loads analysis, the vast majority of single-family home records examined for sizing did not need a water heater with this much hot water delivery capability, given their maximum calculated hot water loads.

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

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

Chapter 7 of the NOPR TSD provides details of DOE's energy use analysis and sizing.

F. Life-Cycle Cost and Payback Period Analysis

The purpose of the LCC and PBP analysis is to analyze the effects of potential amended energy conservation standards on consumers of CWH equipment by determining how a potential amended standard affects their operating expenses (usually decreased) and their total installed costs (usually increased). DOE used the following two metrics to measure consumer impacts:

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

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

DOE conducted the LCC and PBP analyses using a commercially-available spreadsheet tool and a purpose-built spreadsheet model, available on DOE's website.[67] This spreadsheet model developed by DOE accounts for variability in energy use and prices, installation costs, repair and maintenance costs, and energy costs. As a result, the LCC results are also displayed as distributions of impacts compared to the no-new-standards-case (without amended standards) conditions. The results of DOE's LCC and PBP analysis are summarized in section V.B.1.a of this NOPR and described in detail in chapter 8 of the NOPR TSD.

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

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

DOE modeled uncertainty for specific inputs to the LCC and PBP analysis by using Monte Carlo simulation coupled with the corresponding probability distributions, including distributions describing efficiency of units shipped in the no-new-standards case. The Monte Carlo simulations randomly sample input values from the probability distributions and CWH equipment user samples. For this rulemaking, the Monte Carlo approach is implemented in MS Excel together with the Crystal Ball™ add-on.[68] Then, the model calculated the LCC and PBP for equipment at each efficiency level for the 10,000 simulations using the sampled inputs. More details on the incorporation of uncertainty and variability in the LCC are available in appendix 8B of the NOPR TSD.

For the May 2016 CWH ECS NOPR, DOE analyzed the potential for variability by performing the LCC and PBP calculations on a nationally representative sample of individual commercial and residential buildings. This same general process was used for this NOPR analysis, however, with updates to the data set. One update was switching to CBECS 2012 consistent with DOE's general practice of relying on updated data sources to the extent practicable and appropriate.[69] DOE notes that the CBECS 2012 microdata needed for its analysis were not available when DOE conducted the May 2016 CWH ECS NOPR analysis; hence, DOE used CBECS 2003 (the most recent available version at the time) for the NOPR analysis. In this NOPR, DOE updated its LCC model to use EIA's CBECS 2012 microdata that became available in May 2016.[70] DOE investigated but did not update to the 2015 RECS. In reviewing the 2015 RECS, DOE noted the absence of information on the number of apartments in buildings with an apartment reference in the database; the removal of the number of building floors for multifamily buildings with an apartment reference in the database; a reduction in the available occupant age data; and the removal of characteristics data describing whether an occupant directly pays for hot water usage—all of which were variables from the 2009 RECS database that DOE used to model water usage.

Following is a discussion of the development and validation of DOE's LCC model. Across its energy conservation standards rulemakings, DOE incorporates tools that enable stakeholders to reproduce DOE's published rulemaking results. DOE routinely utilizes Monte Carlo simulations using Crystal Ball for LCC model simulation purposes. More specifically, utilizing a spreadsheet program with Crystal Ball enables DOE to test the combined variability in different input parameters on the final life-cycle performance of the equipment. The CWH LCC model specifically includes macros to run the standards analysis with default settings that enable stakeholders to download the LCC model, run it on their own computers, and reproduce results published in this NOPR.[71] To validate models, DOE develops models with

[67] DOE's web page for commercial water heating equipment is available at *www1.eere.energy.gov/buildings/appliance_standards/standards.aspx?productid=36.* Last accessed on July 7, 2021.

[68] Crystal Ball™ is commercially-available software tool to facilitate the creation of these types of models by generating probability distributions and summarizing results within Excel, available at *www.oracle.com/middleware/technologies/crystalball/* (last accessed July 12, 2021).

[69] DOE utilized the building types defined in CBECS 2012, as well as residential buildings defined in RECS 2009. More information on the types of buildings considered is discussed later in this section. CBECS: *www.eia.gov/consumption/commercial/data/2012/* and RECS: *www.eia.gov/consumption/residential/data/2009/.* Both links last accessed on July 12, 2021.

[70] CBECS 2018 microdata were not available in early July 2021, when the analyses for this NOPR were completed.

[71] To reiterate, DOE's web page for commercial water heating equipment is available at *www1.eere.energy.gov/buildings/appliance_standards/standards.aspx?productid=36.*

contractors familiar with Crystal Ball and Monte Carlo tools and other models generally, and regularly tests the models during development, both at average and atypical (extreme) conditions. DOE further notes that the LCC model using the Crystal Ball software can output the assumed values and results of each assumption and provide forecasted results for each iteration in the Monte Carlo simulation, if desired by stakeholders to review or trace the output. In addition, it is possible to directly modify the assumption cells in the model to examine impacts of changes to assumptions on the LCC, and, in fact, DOE relies on both of these techniques for model testing.[72] DOE additionally seeks expert validation by going through a comprehensive stakeholder review of the assumptions and making its models and TSD publicly available during the comment period during each phase of its regulatory proceedings. DOE uses the Monte Carlo models for predicting the impact of future standards, a use different than many other uses that are envisioned generally for Monte Carlo tools (like industrial process examination), so direct validation against data demonstrating the impact of future standards is not possible. With regard to specifying correlations between inputs as part of modeling practices, DOE notes that while one can specify correlation parameters between two variables where such correlation and the data to provide for the level of correlation are known, specifying such correlations is not necessary to maintain the general integrity and accuracy of the analytical framework. Variable values may be selected based on other coding decisions unique to each iteration (*e.g.,* correlation with building type or location or vintage) without specific reference to correlation variables, and DOE does this routinely. For instance, entering water temperature and fuel costs are effectively correlated based on data and the use of the geographic region, which impacts both through the available data or models. The use of explicit correlations between Crystal Ball variables, where data are available to determine or represent a degree of correlation, absent other influences, would be useful, but often, DOE's experience is that the data to express the degree of correlation are not available and are influenced by other factors already dealt with explicitly in the model framework.

In response to the withdrawn 2016 NOPR, Spire commented that certain simulation trials may be unrealistic, citing an example of a storage water heater being replaced by multiple tankless units in a vintage 1960 multi-story building. Spire considers this scenario to be highly unlikely, describing tankless units as point-of-use water heaters and stating that multiple units may need to be installed to provide the same service as a single central commercial water heater and that the complexity goes far beyond a single one-for-one replacement scenario due to multiple runs of gas lines, venting, and electrical supply required, as well as the need for localized venting; Spire argued that while DOE's development and usage of CBECS N-Weights discounts the number of such scenarios in the data set used by DOE, it does not solve the problem caused by the inclusion of unreasonable scenarios. (Spire, No. 45 at p. 22)

The unlikely scenario of replacing a storage water heater by multiple tankless units does not reflect a purposeful replacement scenario but results from using existing CBECS data to develop hot water load scenarios for newer water heating technologies (*i.e.,* tankless units), the use of which is not identified specifically in CBECS data. However, to address potentially unlikely installation scenarios, DOE modified its energy use analysis for tankless water heaters for this NOPR to use only building stock with construction dates of 1980 or later, reflecting more recent construction, in its hot water load analysis.

DOE calculated the LCC and PBP for all commercial consumers as if each would purchase a new CWH unit in the year that compliance with amended standards is required. As previously discussed, DOE is conducting this rulemaking pursuant to its 6-year-lookback authority under 42 U.S.C. 6313(a)(6)(C). At the time of preparation of the NOPR analyses, the expected issuance date was 2015, leading to an anticipated final rule publication in 2016. For this NOPR, DOE relied on 2023 as the expected publication date of a final rule. EPCA states that amended standards prescribed under this subsection shall apply to equipment manufactured after a date that is the later of (I) the date that is 3 years after publication of the final rule establishing a new standard or (II) the date that is 6 years after the effective date of the current standard for a covered equipment. (42 U.S.C. 6313(a)(6)(C)(iv)) The date under clause (I), projected to be 2026, is later than the date under clause (II), which is 2009. Therefore, for the purposes of its analysis for this NOPR, DOE used January 1, 2026 as the beginning of compliance with potential amended standards for CWH equipment.

1. Approach

Recognizing that each consumer that uses CWH equipment is unique, DOE analyzed variability and uncertainty by performing the LCC and PBP calculations on a nationally representative stock of commercial and residential buildings. Commercial buildings can be categorized based on their specific activity, and DOE considered commercial buildings such as offices (small, medium, and large), stand-alone retail and strip-malls, schools (primary and secondary), hospitals and outpatient healthcare facilities, hotels (small and large), warehouses, restaurants (quick service and full service), assemblies, nursing homes, and dormitories. These encompass 89.4 percent of the total sample of commercial building stock in the United States. The residential buildings can be categorized based on the type of housing unit, and DOE considered single-family (attached and detached) and multi-family (with 2–4 units and 5+ units) buildings in its analysis. This encompassed 95.5 percent of the total sample of residential building stock in the United States, though not all of this sample would use CWH equipment. DOE developed financial data appropriate for the consumers in each business and building type. Each type of building has typical consumers who have different costs of financing because of the nature of the business. DOE derived the financing costs based on data from the Damodaran Online website.[73] For residential applications, the entire population was categorized into six income bins, and DOE developed the probability distribution of real interest rates for each income bin by using data from the Federal Reserve Board's Survey of Consumer Finances.[74]

The LCC analysis used the estimated annual energy use for every unit of CWH equipment described in section

[72] The model being discussed in this section, the LCC, has few if any locked cells, meaning most if not all cells are available for editing by users as stated in the text. DOE does in some cases lock cells and worksheets in order to protect proprietary data. Such is not the case with the LCC model used in this rulemaking, so users should be able to edit assumptions in this model.

[73] *Damodaran Online.* Commercial Applications. Available at *pages.stern.nyu.edu/~adamodar/New_Home_Page/home.htm.* Last accessed on July 8, 2021.

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

IV.C of this NOPR. Aside from energy use, other important factors influencing the LCC and PBP analyses are energy prices, installation costs, and equipment distribution markups. At the national level, the LCC spreadsheets explicitly model both the uncertainty and the variability in the model's inputs, using probability distribution functions.

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

2. Life-Cycle Cost Inputs

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

TABLE IV.19—SUMMARY OF INPUTS AND KEY ASSUMPTIONS USED IN THE LCC AND PBP ANALYSES

Inputs	Description
Affecting Installed Costs	
Product Cost	Derived by multiplying manufacturer sales price or MSP (calculated in the engineering analysis) by distribution channel markups, as needed, plus sales tax from the markups analysis.
Installation Cost	Installation cost includes installation labor, installer overhead, and any miscellaneous materials and parts, derived principally from RS Means 2021 data books [A B C] and converted to 2020$.
Affecting Operating Costs	
Annual Energy Use	Annual unit energy consumption for each class of equipment at each efficiency and standby loss level estimated at different locations and by building type using building-specific load models and a population-based mapping of climate locations. The geographic scale used for commercial and residential applications are Census Divisions and reportable domains respectively.
Electricity Prices, Natural Gas Prices.	DOE developed average residential and commercial electricity prices based on EIA Form 861M, using data for 2019.[D] Future electricity prices are projected based on *AEO2021.* DOE developed residential and commercial natural gas prices based on EIA State-level prices in EIA Natural Gas Navigator, using data for 2019.[E] Future natural gas prices are projected based on *AEO2021.*
Maintenance Cost	Annual maintenance cost did not vary as a function of efficiency.
Repair Cost	DOE determined that the materials portion of the repair costs for gas-fired equipment changes with the efficiency level for products. The different combustion systems varied among different efficiency levels, which eventually led to different repair costs.
Affecting Present Value of Annual Operating Cost Savings	
Product Lifetime	Table IV.21 provides lifetime estimates by equipment category. DOE estimated that the average CWH equipment lifetimes range between 10 and 25 years, with the average lifespan dependent on equipment category based on estimates cited in available literature.[F]
Discount Rate	Mean real discount rates (weighted) for all buildings range from 3.2% to 5.0%, for the six income bins relevant to residential applications. For commercial applications, DOE considered mean real discount rates (weighted) from 10 different commercial sectors, and the rates ranged between 3.2% and 7.2%.
Analysis Start Year	Start year for LCC is 2026, which would be the anticipated compliance date for potential amended standards, if such were to be adopted by a final rule of this rulemaking.
Analyzed Efficiency Levels	
Analyzed Efficiency Levels	DOE analyzed baseline efficiency levels and up to five higher thermal efficiency levels. For Residential-Duty Gas-Fired Storage DOE analyzed baseline and up to five higher UEF levels which combine thermal efficiency and standby loss improvements. See the engineering analysis for additional details on selections of efficiency levels and costs.

[A] RSMeans. 2021 Plumbing Costs with RSMeans Data. Available at *www.rsmeans.com/products/books/2021-cost-data-books/2021-plumbing-costs-book.*

[B] RSMeans. 2021 Facilities Maintenance & Repair Costs with RSMeans Data. Available at *www.rsmeans.com/products/books/2021-facilities-maintenance-repair-costs-book.*

[C] RSMeans. Estimating Costs with RSMeans Data, CostWorks CD, Mechanical Costs 2021. Available at *www.rsmeans.com/products/books/2021-mechanical-costs-book.* All RS Means links, last accessed on July 8, 2021.

[D] U.S. Energy Information Administration (EIA). Average Retail Price of Electricity (Form EIA–861). Available at *www.eia.gov/electricity/data/browser/.* Last accessed on February 21, 2021.

[E] U.S. Energy Information Administration (EIA). Average Price of Natural Gas Sold to Commercial Consumers—by State. Available at *www.eia.gov/dnav/ng/ng_pri_sum_a_EPG0_PCS_DMcf_a.htm.* Prices for Residential Consumers are available at the same site using the Data Series menu. Last accessed on February 26, 2021.

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

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

a. Equipment Cost

To calculate equipment costs, DOE multiplied the MPCs developed in the engineering analysis by the markups described previously in section IV.D of this document (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. For each equipment category, the engineering analysis provided contractor costs for the baseline equipment and up to five higher equipment efficiencies. DOE examined whether equipment costs for CWH equipment would change over time. DOE determined that there is no clear historical price trend for CWH equipment. Therefore, DOE used costs established in the engineering analysis directly for determining 2026 equipment costs and future equipment costs (equipment is purchased by the consumer during the first year in 2026 at the estimated equipment price, after which the equipment price remains constant in real dollars). See section IV.H.4 of this document and chapter 10 of the NOPR TSD for more details.

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

b. Installation Costs

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

DOE derived national average installation costs for commercial equipment from data provided in RS Means 2021 data books.[75] RS Means provides estimates for installation costs for CWH units by equipment capacity, as well as cost indices that reflect the variation in installation costs for 295 cities in the United States. The RS Means data identify several cities in each of the 50 States, as well as the District of Columbia. DOE incorporated location-based cost indices into the analysis to capture variation in installation costs, depending on the location of the consumer. Based upon the RS Means data, relationships were developed for each product subcategory to relate the amount of labor to the size of the product—either the storage volume or the input rate. Generally, the RS Means data were in agreement with other national sources, such as the Whitestone Facility Maintenance and Repair Cost Reference.[76]

DOE calculated venting costs for each building in the CBECS and RECS. A variety of installation parameters impact venting costs; among these, DOE simulated the type of installation (new construction or retrofit), water heater type, draft type (atmospheric venting or power venting), building vintage, number of stories, and presence of a chimney. A combination of Crystal Ball variable distributions and MS Excel macros and logic are used to address the identified variables to determine the venting costs for each instance of equipment for each building within the Monte Carlo analysis. With regard to the venting material for condensing equipment, the primary assumptions used in this logic are listed below:

- 25 percent of commercial buildings built prior to 1980 were assumed to have a masonry chimney, and 25 percent of masonry chimneys required relining.
- Condensing equipment with vent diameters smaller than 5 inches were modeled using PVC (polyvinyl chloride) as the vent material.
- Condensing equipment with vent diameters of 8 inches or greater were assigned AL29–4C (superferritic stainless steel) as the vent material.
- Condensing equipment with vent diameters of 5 inches and up to 8 inches were assigned vent material based on a random selection process in which, on average, 50 percent of installations received PVC as the vent material and the remaining received AL29–4C.
- 5 percent of all condensing CWH equipment installations were modeled as direct vent installations. The intake air pipe material for condensing products was modeled as PVC.

Additional details of the venting logic sequence are found in chapter 8 and Appendix 8D of the NOPR TSD.

1. Data Sources

For this NOPR analysis, DOE used the most recent datasets available at the time the analysis was conducted. DOE makes its best attempt to update data to recent datasets available at its various rulemaking stages and has updated the CWH equipment LCC model with the most recent data estimates available for this NOPR, including use of the 2012 CBECs and 2021 RS Means data (including 2021 RS Means Plumbing Costs Data, 2021 RS Means Mechanical Cost Data, and 2021 RS Means Facility Maintenance and Repair Costs).

2. Condensate Removal and Disposal

In response to the withdrawn NOPR, Anonymous, Raypak and AHRI commented about the difficulty in installing condensing water heaters is challenging in buildings lacking floor drains or other ways to drain condensate. (Raypak, No. 41 at p. 7; AHRI, No. 40 at p. 5; Anonymous, No. 21 at p. 2) NEEA stated that the raw costs and application of costs for condensate removal appear high, specifically for the condensate pump, electrical receptacle for the pump, drain line, and heat tape. NEEA argued that since the International Plumbing Code[77] calls for temperature and pressure relief valves to be piped to drain, non-condensing CWH equipment should already have an existing drainage system. NEEA also stated that a condensate neutralizer is not required in certain jurisdictions, though it is good design practice. (NEEA, No. 37 at p. 1)

In response, DOE's LCC analysis accounted for condensate disposal in its installation cost estimates for condensing CWH equipment. The

[75] DOE notes that RS Means publishes data books in one year for use the following year; hence, the 2021 data book has a 2020 copyright date.

[76] Whitestone Research. *The Whitestone Facility Maintenance and Repair Cost Reference 2012–2013 (17th Annual edition).* 2012. Whitestone Research: Santa Barbara, CA.

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

International Plumbing Code is widely used in the U.S. as the model for state and local plumbing codes. Given this fact and given NEEA's information on the International Plumbing Code requirement, DOE revised the assumption of 25 percent used in the withdrawn 2016 NOPR to the assumption for this NOPR of 10 percent of replacement installations requiring the installment and associated costs of a condensate pump and insulated condensate piping to dispose of condensate. For this NOPR analysis, a condensate neutralizer was assigned to 12.5 percent of replacement installations, which was unchanged from the assumption used in the withdrawn 2016 NOPR. For this NOPR, the cost of heat tape was assigned to 10 percent of replacement installations, which was unchanged from the withdrawn 2016 NOPR assumption. The cost of an electrical outlet specifically for heat tape was added for this NOPR in 10 percent of instances in which heat tape was installed. For this NOPR, DOE also conducted research on the appropriate condensate pump size and associated cost for each equipment category, which resulted in an update to the condensate pump assignment for residential-duty and commercial gas-fired storage water heaters. For the withdrawn 2016 NOPR, DOE used one condensate pump for all equipment types while for this NOPR DOE used two sizes of condensate pumps. The representative designs for these residential-duty and commercial gas-fired storage water heaters are met using a condensate pump with a lower volume capacity and gallons-per-hour performance. Chapter 8 of the TSD contains more information on the methodology, raw costs, and sources for the installation cost for condensate removal.

3. Vent Replacement

In response to the withdrawn NOPR stakeholders submitted comments describing challenges building owners may have installing condensing equipment using sidewall venting, while other commenters noted sidewall venting provided a cheaper option in some cases. (AHRI, No. 40 at p. 35; Spire, No. 45 at pp. 34, 35; Bradford White, No. 42 at p. 4; HTP, No. 44 at pp. 1–2; NEEA, No. 37 at p. 1) In both the withdrawn NOPR and in this NOPR DOE conducted its analysis under the assumption that condensing CWH equipment would use the same chase for the venting system as the non-condensing CWH equipment that it replaces. Condensing CWH equipment is not required to sidewall vent exclusively and presents no special limitations restricting vertical vent scenarios. In instances in which a building has a centrally-located mechanical room, relocation of this mechanical room should not be necessary to accommodate condensing CWH equipment. The local building codes that may limit or prohibit sidewall venting in certain buildings should not be a factor for vertical venting systems. To the extent that horizontal natural draft venting is used at a job site, it is indicative that horizontal venting is allowed by the jurisdiction and potentially that vent runs may be different than DOE's vertical venting assumption (shorter vertically, but with a horizontal length component). DOE received no information from commenters on the relative frequency of less-costly sidewall venting installations nor did DOE receive information or data suggesting that DOE's assumption of vertical venting using the existing chase is unsound. Therefore, DOE has maintained its venting methodology and associated venting costs for scenarios in which non-condensing CWH equipment is replaced by condensing CWH equipment.

NEEA recommended that DOE account for the cost of a high and low sidewall air ducts (per mechanical code) to the installation cost of non-condensing CWH equipment. (NEEA, No. 37 at p. 2) In response, DOE acknowledges that all combustion appliances require adequate air for combustion and that in installations where adequate combustion air is not provided through infiltration alone, high and low sidewall air ducts providing ventilation air are an installation option alone, or in combination with infiltration. The requirement for adequate combustion air exists regardless of whether naturally-vented or fan-assisted vent systems are used, but is not required for direct vent systems where combustion air is provided through dedicated means per manufacturers specifications. While there are certain differences in the requirements for fan-assisted versus naturally-vented equipment, the cost of providing for combustion air is similar for non-condensing or condensing non-direct-vent CWH equipment, and in fact, minimum room volume requirements before requiring separate ventilation openings are larger for natural draft versus fan-assisted combustion appliances. Direct vent equipment provides another option where fan-assisted combustion equipment is used, and may provide better control of outside air into a building as well as providing combustion air that is free from indoor contaminants that can damage water heaters in certain circumstances (where necessary). Another option is to install a mechanical combustion air system (*e.g.,* ''fan in a can'') in the room to ensure proper make-up air for the equipment. NEEA did not provide information or data indicating how common these situations are in buildings, and DOE was unable to find this information in its research, and the Department has concluded that the cost to provide adequate combustion air will be similar for non-condensing and condensing CWH equipment.

In response to the withdrawn NOPR NEEA commented that sleeving of vents in replacement scenarios avoids the cost of removing the existing venting system while Spire asked for clarification as to whether DOE considers existing vent systems to be sleeved. (NEEA, No. 37 at p. 2; Spire, Public Meeting Transcript, No. 20 at p. 83) In response, DOE incorporated the sleeving of existing vent systems in its SNOPR analysis. For existing buildings with natural draft (B-vent type) venting systems that have no elbows and possess vent lengths less than or equal to 30 feet, DOE assigned sleeving of the existing vent with PVC venting to 50 percent of replacement scenarios. DOE's assumption of 50 percent sleeving under these conditions presumes that sleeving of new vents can be done but that with plastic piping other limitations to sleeving, including access for joints, may present themselves. While DOE recognizes that with other venting systems, particularly polypropylene or stainless flexible venting, additional sleeving options are possible, DOE's existing analysis adequately accounts for the potential for sleeved venting.

Stakeholders commented on the withdrawn NOPR that jurisdictions in certain parts of the country do not allow for non-metallic vents (an estimated 5 percent of installations), that many local municipalities disallow PVC usage when the vent diameter is greater than 4 inches, and that polypropylene as a venting material is an option available to consumers that is widely used due to the growing number of municipality building codes and contractor requests calling for the use of this vent material. (*See* (A.O. Smith, No. 39 at p. 12; Rheem, No. 43, at p. 22; Rheem, No. 43, at p. 22; Bradford White, No. 42 at p. 8) DOE conducted further research as to the local or regional jurisdictions that prohibit certain vent materials for CWH equipment installation. While DOE found that PVC vent material is disallowed in certain jurisdictions (*e.g.,* New York, NY), DOE did not identify jurisdictions in which non-metallic vents are disallowed, and comments on the withdrawn NOPR did not provide examples for DOE to investigate. DOE also reviewed manufacturer product literature and costs for polypropylene vents. DOE did not identify physical limitations for using polypropylene venting with condensing CWH equipment. Polypropylene material costs have decreased significantly with increasing demand, and fewer labor hours are required to install polypropylene venting systems, which are found as ''snap-together'' gasketed systems, than for PVC or CPVC venting. For jurisdictions prohibiting PVC venting, polypropylene venting is a viable alternative and if it becomes more commonly used DOE expects it will be an even more viable, cost-competitive alternative by 2026. While polypropylene venting has the potential in some cases to reduce installation costs, DOE did not modify its analysis for this NOPR to explicitly include polypropylene venting.

PHCC argued that, in some cases, vent replacement can be physically impossible and prohibitively expensive due to the uniqueness of each replacement situation. (PHCC, No. 34 at p. 1) Spire stated that DOE's estimated installation and venting costs are too low in cases where installations are intrinsically difficult. (Spire, No. 45 at pp. 44–45) For this NOPR DOE's analysis accounts for installation costs in the commercial and residential sectors for both replacement and new construction markets, along with an appropriate set of installation scenarios within each market and sector combination. Equipment installation and removal costs are separate from venting system installation and removal costs. The equipment installation labor hours for representative CWH models ranged from 4 to 22.4 hours, depending on the equipment category. The labor hours to remove CWH equipment in replacement situations were determined to be an additional 37.5 percent of the installation labor hours on average, meaning they ranged from an additional 1.5 to 8.4 hours depending on the equipment category. These labor hour calculations were based on a linear regression formula using data from the RS Means Facilities Construction Cost Data, ENR Mechanical Cost book, and Whitestone Facility Maintenance and Repair Cost Reference. This formula escalated equipment installation labor hours based on the input capacity and/or volume of the CWH equipment, as expressed in the sources that DOE relied upon. DOE has found no information that suggests basic CWH equipment installation or removal cost varies based on thermal efficiency rather than input capacity and/or volume. DOE accepts the methodologies of its sources that the activities required to install minimum-efficiency and high-efficiency equipment are inherently similar. This approach to developing costs for CWH equipment installation or removal was not changed from the withdrawn NOPR.

In addition to equipment installation and removal, DOE accounted for the labor hours to install and remove venting, scaled to the vent length in linear feet and/or the number of components (*e.g.,* elbows) in the venting system. These costs differed based on the vent material and diameter involved in the installation. For example, the labor to install PVC venting for condensing CWH equipment in the commercial sector ranged from 0.302 hours per linear foot for three-inch diameter vents to 0.333 hours per linear foot for 4-inch diameter vents. [78] The labor to install Type-B vent in the commercial sector for non-condensing CWH equipment ranged from 0.235 hours per linear foot for 4-inch diameter vents to 0.286 hours per linear foot for 7-inch diameter vents.[79] The labor rates in DOE's analysis depended on the crew type conducting the installation, region in which the installation occurred, and whether venting was installed in residential or commercial buildings. For the installation of Type-B venting for non-condensing CWH equipment, average labor rates (including overhead and profit) ranged from $65 per hour in the residential sector to $87 per hour in the commercial sector. [80] For the installation of PVC venting for condensing CWH equipment, average labor rates used by DOE (including overhead and profit) ranged from $66 per hour in the residential sector to $89 per hour in the commercial sector.[81] Regional adjustments to these labor rates called for multipliers ranging from 0.59 (South Carolina and North Carolina) to 1.68 (New York).[82] For this NOPR, DOE did not further adjust labor rates for venting except to use the most up-to-date source data.

In addition to accounting for equipment installation and removal, and venting installation and removal, DOE also incorporated an appropriate set of installation cost additions and subtractions, which included labor and material, arising from unique circumstances in replacement scenarios. These installation costs included reusing existing vent systems (when replacing non-condensing CWH equipment with similar non-condensing CWH equipment), relining of chimneys, installing condensate drainage, and sleeving of existing vent systems with certain replacement venting systems, introduced in this NOPR analysis. DOE did not incorporate the costs of sealing off chases and roof vents or moving mechanical rooms because it is logical that condensing CWH equipment would reside in the same location and use the same chase as the non-condensing CWH equipment it replaced. DOE found this to be appropriate since there are no technological limitations preventing condensing CWH equipment from using vertical venting systems.

4. Extraordinary Venting Cost Adder

In response to the withdrawn NOPR, PHCC and Spire argued that, in some cases, vent replacement can be physically impossible and/or prohibitively expensive in cases where installations are intrinsically difficult. (PHCC, No. 34 at p. 1; Spire, No. 45 at pp. 44–45) DOE acknowledges the possibility that its analysis of installation costs may not capture outlier installation scenarios that involve uncommon building conditions that may further reduce or increase installation costs. Neither PHCC nor Spire provided data or evidence to substantiate the extent that these unique, additional installation challenges occur for condensing CWH equipment in buildings, descriptions of what would be necessary to resolve these installations challenges, or amount of labor and materials required to perform the solution. DOE expects that these situations would be small in number and that it has captured an appropriate set of installation scenarios that are typical of residential and commercial buildings. For this NOPR, DOE researched the question of the prevalence and cost of extraordinarily costly installations. The one source identified that could be used to quantify extraordinary vent costs was the report submitted by NEEA in DOE Docket EERE–2018–BT–STD–0018.[83] Using this

[78] RSMeans. Estimating Costs with RSMeans Data, CostWorks CD, Mechanical Costs 2021.

[79] *Id.*

[80] RSMeans. Estimating Costs with RSMeans Data, CostWorks CD, Mechanical Costs 2021.

[81] *Id.*

[82] *Id.*

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

as a reference, DOE implemented an extraordinary venting cost adder, which was included in the SNOPR LCC model as a feature of the main case.

To account for the extraordinarily expensive venting installation costs hypothesized by stakeholders as discussed in section IV.F.2.b of this NOPR, DOE added an extraordinary vent cost adder. This is based on the report submitted by NEEA. *Id.* In that report it was stated that due to vent configurations, between 1 and 2 percent of replacements might experience extraordinary costs between 100 and 200 percent above the average installation cost. Because there is no clear linkage between specific situations and extraordinary costs, DOE implemented this by adding for each equipment category two additional variables. One is a probability of occurrence and the second is the multiplier. For 2 percent of cases, DOE assumes a multiplier between 200 percent and 300 percent. In all cases, the LCC model estimates the total installation cost, and multiplies it by the multiplier. In 98 percent of cases, the multiplier is equal to 1.00, or 100 percent. When the LCC model selects the extraordinary installation cost case, it also selects a multiplier between 200 and 300 percent to multiply the estimated installation cost.

Issue 4: DOE seeks comments on the extraordinary venting cost adder. Specifically, DOE seeks data to estimate the fraction of consumers that might incur extraordinary costs, and the level of such extraordinary costs.

5. Common Venting

Spire and AO Smith commented on issues related to common venting of non-condensing equipment including assets being potentially ''stranded'' or needing to be prematurely retired and the cost of engineering a solution. (Spire, No. 45 at pp. 33, 34; AO Smith, No. 39 at p. 12) AHRI commented that one way to replace common vented, non-condensing CWH equipment is to replace all water heaters simultaneously. (AHRI, Public Meeting Transcript, No. 20 at pp. 89–90)

DOE acknowledges that certain CWH equipment installations are commonly vented in certain building applications in which it is feasible. However, in these instances, the CWH equipment typically is not commonly vented with other, disparate gas-fired equipment (like furnaces). Instead, multiple units of CWH equipment are common vented together since the CWH equipment typically operates in unison, calling for a specific vent size. Common venting disparate gas-fired equipment complicates the design and sizing of the common vent, since it needs to accommodate exhaust of a wide range of flue gas volume due to the different operating profiles and flue capacities required for disparate equipment. When multiple units of CWH equipment are common vented, building engineers typically design the common vent system to suit a specific number of units of CWH equipment with certain specifications. The installation of these units typically occurs all at one time. As a result, each unit should have the similar expected lifetime and replacement cycle. Therefore, when one unit fails and requires replacement, the other units sharing the common vent should also be nearing the end of their lifetimes. In this scenario, building engineers will often replace all of the units at one time for sake of simplicity, time, cost, and risk avoidance. Thus, the stranded cost of any naturally-drafted, non-condensing CWH equipment due to this NOPR would have marginal residual value, which often would have been relinquished regardless of this NOPR. In addition, polypropylene common vent kits are available in the market to accommodate the common venting of condensing CWH equipment, and DOE is unaware of building codes issues to prevent such kits from being used widely. This means condensing CWH equipment could be installed in the same location as the naturally-vented, non-condensing CWH equipment that it replaces. Spire, AHRI, and A.O. Smith did not provide information supporting their claim that the building applications and circumstances that call for the design and installation of a common venting system. Moreover, commenters did not indicate how typical common venting is in the commercial and residential building stock, which would allow for an accounting of common venting where it has a substantial impact on the analysis. For all of these reasons, DOE determined that stranded gas-fired equipment due to common venting circumstances would not have a substantial impact on the results of its analysis. The SNOPR retained the assumption embodied in the NOPR analysis that common venting does not impose specific costs that must be captured in the installation cost analysis.

6. Vent Sizing/Material Cost

Raypak commented that the cost used by DOE for replacing venting systems is likely understated due to the selected input capacity for the representative designs of commercial gas-fired tankless water heaters and commercial gas-fired instantaneous circulating water heaters and hot water supply boilers. Raypak argues that higher-capacity commercial CWH equipment calls for larger vent diameters that require more expensive vent material (*i.e.,* AL29–4C) than the material currently used in DOE's analysis (*i.e.,* PVC). (Raypak, No. 41 at p. 7) In response, DOE's analysis uses representative models for each CWH equipment category as described in IV.C.3.

These representative models were determined through research of the most common specifications of models within the equipment category in the market. DOE acknowledges that CWH equipment with higher input capacities calls for vents with larger diameters, and, thus, requires AL29–4C as the venting material for condensing CWH equipment. An examination of the installed costs for vents from 4–10 inches in diameters based on straight vent pipe and national average labor rates suggests the AL29–4C double wall vent is approximately 50 percent more expensive per foot on average than PVC. However, as vent diameter increases linearly in size, the input capacity for the CWH equipment sized to the vent diameter increases roughly as the square of the vent diameter due to the volume of exhaust that can travel through the vent cross-sectional area at the same pressure. CWH equipment with such high input capacities will be installed in buildings with higher maximum and average daily loads, which will result in higher energy and monetized energy cost savings relative to the roughly linear cost increase in vent installation. Therefore, to the extent that CWH equipment requiring larger diameter venting is prevalent in the market, it suggests that DOE's LCC analysis results may be conservative in terms of such CWH equipment.

7. Masonry Chimney/Chimney Relining

Bradford White questioned the validity of DOE's assumptions that 25 percent of buildings built prior to 1980 have a masonry chimney, and that 25 percent of those chimneys need relining. (Bradford White, No. 42 at p. 8)

In the withdrawn NOPR, DOE assumed that 25 percent of pre-1980 buildings have masonry chimneys and that 25 percent need relining. DOE asked for input on these and other primary assumptions used in the logic underlying the calculation of venting costs. While DOE acknowledges Bradford White's uncertainty about

comment/EERE-2018-BT-STD-0018-0062. Last accessed July 8, 2021.

these assumptions, DOE did not receive information or data on the percentage of buildings built prior to 1980 with a masonry chimney and the percentage of those chimneys that require relining. Because no information has been identified to cause DOE to alter the original assumptions, this NOPR continues to use the assumptions that 25 percent of buildings constructed prior to 1980 have masonry chimneys, and 25 percent of those buildings need a relining of the chimney.

8. Downtime During Replacement

In response to the withdrawn NOPR, several stakeholders asked for clarification as to whether the downtime to switch from a non-condensing CWH equipment to condensing equipment was included in DOE's analysis, or encouraged DOE to include tangential factors like downtime in the analysis. (PVI, Public Meeting Transcript, No. 20 at pp. 85–86; AHRI, No. 40 at p. 5–6; Rheem, No. 43 at pp. 7, 15, 23; Raypak, No. 41 at pp. 4–5; NPGA, No. 32 at p. 3) In response, DOE's research indicates that consumers sensitive to the downtime incurred during CWH equipment replacement, such as in hotel and restaurant building applications, already plan ahead to limit the downtime of equipment replacement.[84] These consumers already must schedule planned replacements during off hours or low-use periods to limit the impact on business operation. Therefore, DOE did not account for the loss of business in its LCC analysis.

9. Fuel Switching, Cost Build-Up Versus Survey, Other Comments

DOE's LCC analysis accounts for consumers who experience a net cost due to a payback that is longer than the equipment lifetime of the more-efficient CWH equipment (*i.e.,* non-cost-effective scenario). The results of DOE's calculations of average lifetime cost and percent of consumers experiencing a net cost are presented for each equipment category in chapter 8 of the NOPR TSD. Table V.4 through Table V.12 of this NOPR present LCC savings and PBP results by TSL. DOE's review of fuel switching is available in section IV.H.2 of this NOPR.

In comments on the withdrawn NOPR, two stakeholders claimed that using a cost build-up approach rather than surveys of contractor quotes, leads to systematically understated installation costs. (Spire, No. 45 at pp. 20, 21; AHRI, No. 40 at pp. 35, 36) In response, DOE relied primarily on data from RS Means, Whitestone, and ENR to develop its installation costs. These resources provided itemized data on the installation and removal costs of both equipment and venting systems, as well as the installation costs of condensate drainage systems, electrical outlets, and chimney relining. The itemization of these costs was at the component level for both labor and material, and in both the commercial and residential sectors, which allowed DOE to develop an appropriate set of installation scenarios to factor into the LCC analysis. The use of these resources also provided DOE with a consistent evaluation of costs with a consistent set of location adjustments for each residential and commercial region included in the analysis. DOE notes that surveys of existing contractor quotes may not adequately separate equipment costs from installation costs since installing contractors would commonly be selling and marking up equipment as well as installation labor. Thus, use of surveys would not provide the level of detailed information needed to assess installation costs. For these reasons, the sources relied upon were nationally representative and appropriate for the development of installation costs, as were the methodologies used in the withdrawn NOPR. For this NOPR, DOE continued to use a built-up cost approach to installed cost estimation.

The Joint Advocates referred DOE to a commercial kitchens service center for information on installation costs. (Joint Advocates, Public Meeting Transcript, No. 20 at p. 87) DOE believes this reference is to the Fisher-Nickel Food Technology Service Center. DOE reviewed the Installation Considerations section of the Fisher-Nickel ''Design Guide for Improving Commercial Kitchen Hot Water System'' [85] performance in its analysis. DOE's analysis accounts for the installation recommendations included in this resource, such as the installation of a condensate neutralizer for condensate drainage and use of PVC vent material for condensing CWH equipment. In addition, DOE relied on this resource for certain components of its energy use analysis. Thus, DOE has properly considered this resource in this NOPR analysis.

In response to the withdrawn NOPR four stakeholders mentioned the potential impacts of costs associated with asbestos treatment in venting retrofit cases and asked if asbestos was considered by DOE and/or stated that the presence of asbestos could drive up the costs to change to a new vent system. (Bradford White, No. 42 at pp. 8–9; A.O. Smith, No. 39 at pp. 3, 13; NegaWatt, Public Meeting Transcript, No. 20 at p. 90; CA IOUs, No. 28 at p. 3) In response to these comments, DOE researched the prevalence and vintage of asbestos insulation in venting systems. Asbestos-lined vents were installed in the 1970s to insulate single-wall vents as a safety precaution (*i.e.,* prevent safety hazards resulting from hot vent temperatures). This practice was phased out in the 1980s due to the human health risks associated with asbestos material. In addition, EPAct 1992 mandated a minimum thermal efficiency of 78 percent for CWH equipment, which went into effect in 1994. As a result of this legislation, many consumers replacing CWH equipment also needed to replace the venting system due to the improper vent diameter of their existing system, at which time asbestos issues likely would have been addressed. Commenters seemed to agree this is an uncommon situation now and would be less common over time. DOE also notes that the deterioration of the asbestos-containing venting over time implies that this is a pre-existing building concern and that many of these vents would need to be replaced or circumvented regardless, which when it occurs, points to situations where an existing vent is no longer reusable. DOE agrees that incorporation of costs for asbestos removal would increase the cost of venting generally, but due to these historical circumstances and the need to replace deteriorating and unsafe existing vents, generally, it is unnecessary to account for the additional cost of removing asbestos-lined vents since they are uncommon and will be even less common by 2026. DOE notes that the approach taken for this NOPR analysis is unchanged from the withdrawn NOPR analysis in this regard.

c. Annual Energy Consumption

DOE estimated the annual electricity and natural gas consumed by each category of CWH equipment, by efficiency and standby loss level, based on the energy use analysis described in section IV.E and in chapter 7 of the NOPR TSD.

[84] For examples of the types of steps hotels take to avoid downtime and the planning performed to meet customer needs with minimum downtimes, see *www.usatoday.com/story/travel/hotels/2018/12/03/hot-showers-hotels/2154259002/*or *continuingeducation.bnpmedia.com/courses/watts/water-safety-and-efficiency-in-hospitality-buildings/4/.*

[85] Fisher-Nickel. *Design Guide: Improving Commercial Kitchen Hot Water System: Energy Efficient Heating, Delivery and Use.* March 26, 2010.

d. Energy Prices

Electricity and natural gas prices are used to convert changes in the energy consumption from higher-efficiency equipment into energy cost savings. It is important to consider regional differences in electricity and natural gas prices because the variation in those prices can impact electricity and natural gas consumption savings and equipment costs across the country. DOE determined average effective commercial electricity prices [86] and commercial natural gas prices [87] at the State level from EIA data for 2019. DOE used data from EIA's Form 861 [88] to calculate commercial and residential sector electricity prices, and EIA's Natural Gas Navigator [89] to calculate commercial and residential sector natural gas prices. Future energy prices were projected using trends from the EIA's *AEO2021*.[90] This approach captured a wide range of commercial electricity and natural gas prices across the United States.

CBECS and RECS report data based on different geographic scales. The various States in the United States are aggregated into different geographic scales such as Census Divisions (for CBECS) and reportable domains (for RECS). Hence, DOE weighted electricity and natural gas prices in each State based on the cumulative population in the cluster of one or more States that comprise each Census Division or reportable domain respectively. See appendix 8C of the NOPR TSD for further details.

The electricity and natural gas price trends provide the relative change in electricity and natural gas costs for future years. DOE used the *AEO2021* Reference case to provide the default electricity and natural gas price forecast scenarios. DOE extrapolated the trend in values at the Census Division level to establish prices beyond 2050.

[86] U.S. Energy Information Administration (EIA). Form EIA–861M Database Monthly Electric Utility Sales and Revenue Data (aggregated: 1990–current). Available at *www.eia.gov/electricity/data/eia861m/*. Last accessed on April 16, 2021.

[87] U.S. Energy Information Administration (EIA). Natural Gas Prices. Available at *www.eia.gov/dnav/ng/ng_pri_sum_a_EPG0_PCS_DMcf_a.htm*. Last accessed on February 26, 2021.

[88] U.S. Energy Information Administration (EIA). ''Average retail price of electricity;'' pre-generated report 5.6, average retail price of electricity to ultimate customers by end-use sector, by state. Available at *www.eia.gov/electricity/data/browser/*. Last accessed on February 21, 2021.

[89] U.S. Energy Information Administration (EIA). Natural Gas Navigator. Available at *www.eia.gov/dnav/ng/ng_pri_sum_a_EPG0_FWA_DMcf_a.htm*. Last accessed on February 26, 2021.

[90] U.S. Energy Information Administration (EIA). *Annual Energy Outlook 2021 with Projections to 2050: Narrative*. February 2021. Available at *www.eia.gov/outlooks/aeo/*.

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

DOE received comments on its marginal energy prices and marginal energy price factors, whether they represent the true marginal gas and electric energy costs, and the accuracy with which they represent the marginal energy costs paid by larger load consumers, in the withdrawn 2016 NOPR. Spire commented that DOE's needs to consider how changes in energy consumption are reflected in consumer energy bills based upon actual tariffs. (AGA and APGA, No. 35 at pp. 5, 8–9; Spire, No. 45 at pp. 36, 40; EEI, No. 38 at pp. 3–5).

Regarding the usage of EIA data for development of marginal energy costs and comparisons to tariff data, DOE emphasizes that the EIA data provide complete coverage of all utilities and all customers, including larger commercial and industrial utility customers that may have discounted energy prices. The actual rates paid by individual customers are captured and reflected in the EIA data and are averaged over all customers in a state. DOE has previously compared these two approaches for determining marginal energy price factors in the residential sector. In a September 2016 supplemental notice of proposed rulemaking for residential furnaces, DOE compared its marginal natural gas price approach using EIA data with marginal natural gas price factors determined from residential tariffs submitted by stakeholders. 81 FR 65719, 65784 (Sept. 23, 2016). The submitted tariffs represented only a small subset of utilities and states and were not nationally representative, but DOE found that its marginal price factors were generally comparable to those computed from the tariff data (averaging across rate tiers).[91] DOE noted that a full tariff-based analysis would require information on each household's total baseline gas consumption (to establish which rate tier is applicable) and how many customers are served by a utility on a given tariff. These data were not available in the public domain. By relying on EIA data, DOE noted, its marginal price factors represented all utilities and all states, averaging over all customers, and was therefore ''more representative of a large group of consumers with diverse baseline gas usage levels than an approach that uses only tariffs.'' 81 FR 65719, 65784. While the above comparative analysis was conducted for residential consumers, the general conclusions regarding the accuracy of EIA data relative to tariff data remain the same for commercial consumers. DOE uses EIA data for determining both residential and commercial electricity prices and the nature of the data is the same for both sectors. DOE further notes that not all operators of CWH equipment are larger load utility customers. As reflected in the building sample derived from CBECS 2012 and RECS 2009 data, there are a range of buildings with varying characteristics, including multi-family residential buildings, that operate CWH equipment. The buildings in the LCC sample have varying hot water heating load, square footage, and water heater capacity. Operators of CWH equipment are varied, some large and some smaller, and thus the determination of the applicable marginal energy price should reflect the average CWH equipment operator.

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

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

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

DOE uses EIA's forecasted energy prices to compute future energy prices indices (for this NOPR, DOE updated forecasts from data published in the *AEO2021* Reference case), and combines those indices with monthly historical energy prices and seasonal marginal price factors in calculating future energy costs in the LCC analysis. For this NOPR, DOE used 2019 EIA energy price data as a starting point and notes that the 2019 historical average natural gas prices are lower than the historical prices used in the withdrawn NOPR. EIA historical price trends and calculated indices are developed in a reasonable manner using the best available data and models, and DOE uses these trends consistently across its regulatory analyses. DOE points out that this NOPR analyzes potential new standards for gas-fired equipment, and that electricity usage for such commercial equipment occurs both during standby and during firing periods (depending on equipment design) and can occur during periods of utility peak usage. While electricity usage and resultant expenditures are significantly lower than fuel (gas)-related expenditures, they do impact the LCC analysis and have been included, using the calculated marginal electricity costs. DOE's use of marginal cost factors for electricity in this analysis, which is based on overall electric expenditures, including those associated with electricity demand, may result in somewhat higher electricity costs than cost figures which omit the impact of demand costs; however, this is appropriate for the current analysis, barring other information on commercial load profiles and demand-peak windows. After careful consideration during the preparation of this NOPR, DOE concluded that it is appropriate to use its existing approach to the development of electric and fuel costs for the LCC and PBP analysis that (1) considers marginal electric and natural gas costs in its economic analysis, (2) reflects seasonal variation in marginal costs, and (3) uses EIA-recommended future energy price escalation rates. DOE maintained this approach for this NOPR.

e. Maintenance Costs

Maintenance costs are the routine annual costs to the consumer of ensuring continued equipment operation. DOE utilized The Whitestone Facility Maintenance and Repair Cost Reference 2012–2013 [92] [93] to determine the amount of labor and material costs required for maintenance of each of the relevant CWH equipment subcategories. Maintenance costs include services such as cleaning the burner and flue and changing anode rods. DOE estimated average annual routine maintenance costs for each class of CWH equipment based on equipment groupings. Table IV.20 presents various maintenance services identified and the amount of labor required to service the equipment covered in the NOPR analysis.

TABLE IV.20—SUMMARY OF MAINTENANCE LABOR HOURS AND SCHEDULE USED IN THE LCC AND PBP ANALYSES

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

Because data were not available to indicate how maintenance costs vary with equipment efficiency, DOE used preventive maintenance costs that remain constant as equipment efficiency increases. Additional information relating to maintenance of CWH equipment can be found in chapter 8 of the NOPR TSD.

In response to the withdrawn NOPR, PHCC and Bradford White argued that maintenance of condensing equipment takes more labor time when compared to non-condensing equipment, *i.e.,* that maintenance costs are not independent of thermal efficiency. (PHCC, No. 34 at p. 2; Bradford White, No. 42 at pp. 9–10) In preparing this NOPR, DOE reviewed the manuals of non-condensing and condensing CWH equipment for a number of major manufacturers (listed in NOPR TSD Appendix 8E). The maintenance sections of these manuals provide a detailed list of maintenance activities for the corresponding CWH model. Comparing non-condensing to condensing CWH equipment, DOE identified condensate line inspection as the distinct maintenance activity differentiating the two. This activity is neither sophisticated nor time consuming and not separately included. None of the manuals for condensing CWH equipment provided maintenance activities for controls, enclosures, access

[92] Whitestone Research. *The Whitestone Facility Maintenance and Repair Cost Reference 2012–2013 (17th Annual edition).* 2012. Whitestone Research: Santa Barbara, CA.

[93] The Whitestone Research report is the most recent available from this source. The report was used in the determination of labor hours for maintenance and DOE has found no evidence indicating that maintenance tasks and labor hours have changed except as addressed in subsequent sections of this NOPR.

panels, wiring or motors. This suggests that there may be a confusion between what regular maintenance activities are and what would be considered repair. Accordingly, DOE has decided to maintain its current methodology for assigning the maintenance costs for non-condensing and condensing CWH equipment, with one exception. DOE added an additional 0.0833 labor hours per year [94] for checking condensate neutralizers during annual maintenance work, and $10 per year [95] for replacing the material within the neutralizers.

In response to the withdrawn NOPR PHCC and Rheem commented that DOE's assumption of 0.33 hours for tankless water heater maintenance as too low, with Rheem suggesting a minimum of 0.75 hour. (PHCC, No. 34 at p. 1; Rheem, No. 43 at p. 25) In response, DOE relied on Whitestone Facility Maintenance and Repair Cost Reference [96] for the labor hours required for tankless water heater maintenance in the NOPR. Given the time needed to descale a tankless water heater annually, DOE increased the labor hours for tankless water heater maintenance to 0.75 hours per year, as recommended by Rheem. In addition, DOE conducted research on the maintenance labor activities and associated hours needed to maintain commercial gas-fired instantaneous circulating water heaters and hot water supply boilers. This research involved reviewing guidance in manufacturer product manuals in combination with the estimates in the Whitestone Facility Maintenance and Repair Cost Reference and the RS Means Facilities Maintenance and Repair Cost Data.[97] Using these references, DOE updated the maintenance labor hours from 0.33 to 7.12 for this equipment category. Appendix 8E of the NOPR TSD provides more detail on maintenance labor hours assigned to each equipment category of CWH.

f. Repair Costs

The repair cost is the cost to the consumer of replacing or repairing components that have failed in the CWH equipment.

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

The labor required to repair a subsystem was estimated as 2 hours for combustion systems and 1 hour for combustion controls. Labor costs are based upon servicing by one plumber with overhead and profit included and are based on RSMeans data.[98] Because a repair may not require the complete subsystem replacement, but rather separate components, DOE estimated a typical repair would have material costs of one-half the subsystem total cost, but would require the equivalent labor hours for total subsystem replacement. DOE calculated a cost for repair over the life of a CWH unit with these assumptions, and used that cost or repair in the analysis. A repair year was selected at random over the life for each unit selected in the LCC and the repair cost occurring in that year was discounted to present value for the LCC analysis.

Heat exchanger failure is a unique repair scenario for certain commercial gas-fired instantaneous circulating water heaters and hot water supply boilers and was included in DOE's repair cost analysis. The use of condensing or non-condensing technology determines the rate and timing of heat exchanger failure as well as the cost of repair with an approximately three times greater probability of repair for condensing equipment. DOE's assumptions for the frequency of failure and the mean year of heat exchanger failure were based on a report from the Gas Research Institute (''GRI'') for boilers.[99] The cost of heat exchanger replacement is assumed to be a third of the total water heater replacement cost.

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

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

Where similar component parts and costs were identified that reflected the equipment category and efficiency, DOE's component cost was estimated as the average cost of those replacement components identified. This cost was applied at the frequency identified earlier in this section. DOE understands that this approach may conservatively estimate the total cost of repair for purposes of DOE's analysis, but the percentage of total repair cost remains small compared to the consumer cost and the total installation cost. Additionally, DOE prefers to use this component-level approach to understand the incremental repair cost difference between efficiency levels of equipment. Additional details of this analysis and source references for the subsystem and component costs are found in chapter 8 of the NOPR TSD

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

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

[96] Whitestone Research. *The Whitestone Facility Maintenance and Repair Cost Reference 2012–2013 (17th Annual edition).* 2012. Whitestone Research: Santa Barbara, CA.

[97] RS Means Company. *Facilities Maintenance and Repair Cost Data 2021.* 28th Annual Edition. Available at *https://www.rsmeans.com/products/books/2021-facilities-maintenance-repair-costs-book.*

[98] RSMeans. RSMeans Mechanical Costs Book 2021. Available at *www.rsmeans.com/products/books.*

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

and Appendix 8E of the NOPR TSD. DOE's incorporation and approach to repair costs in the LCC did not change from the NOPR implementation.

Anonymous commented that condensing technology combined with electronic ignition is less reliable. (Anonymous, No. 21 at p. 1) Rheem commented that repair costs increase as a function of thermal efficiency, and asked that DOE present a tailored repair analysis for all TSLs considered. (Rheem, Public Meeting Transcript, No. 20 at p. 127). In response, DOE acknowledges the point and again clarifies that in the LCC model, repair costs do vary as a function of thermal efficiency and are comparatively higher for condensing equipment. DOE did not perform an explicit repair/replace type analysis for CWH equipment, and this is documented in appendix 8E. The largest shipments of CWH equipment are storage water heaters and all commercial water heaters are high cost equipment; therefore, minor repairs that can be addressed with a part exchange (*e.g.,* thermostat repair) are assumed to be done as part of regular repair and maintenance operation during the early life of the equipment. Thus, DOE assumed that most failures leading to replacement in non-condensing equipment are tied to storage-tank leakage, which is not considered a long-term repairable situation given the typical glass-lined steel tanks used. Other repairs, such as combustion system repairs, will be made or not based on the assessment of the remaining tank life. Because this is such a fundamental limitation to the equipment life, DOE tentatively concluded that any repair or replacement consideration will have only a minimal effect on the equipment life and the subsequent LCC and NIA analysis.

g. Product Lifetime

Product lifetime is the age when a unit of CWH equipment is retired from service. DOE used a distribution of lifetimes, with the weighted averages ranging between 10 years and 25 years as shown in Table IV.21, which are based on a review of CWH equipment lifetime estimates found in published studies and online documents. Sources include documents from prior DOE efficiency standards rulemaking processes, LBNL, NREL, the EIA, Federal Energy Management Program, Building Owner and Managers Association, Gas Foodservice Equipment Network, San Francisco Apartment Association, and National Grid.[100] Specific document titles and references are provided in Appendix 8F of the NOPR TSD. DOE applied a distribution to all classes of CWH equipment analyzed. Chapter 8 of the NOPR TSD contains a detailed discussion of CWH equipment lifetimes.

TABLE IV.21—AVERAGE CWH LIFETIME USED IN NOPR ANALYSES

CWH equipment	Average lifetime (years)
Commercial gas-fired storage water heaters and storage-type instantaneous	10
Residential-duty gas-fired storage water heaters	12
Gas-fired instantaneous water heaters and hot water supply boilers:	
Tankless water heaters	17
Circulating water heaters and hot water supply boilers	25

DOE notes that the average lifetime of all equipment covered by this proposed rulemaking is the same for baseline and max-tech thermal efficiency levels. The lifetime selected for each simulation run varies, but the weighted-average lifetime is the same across all thermal efficiency levels. DOE does not have data to suggest that the lifetime of condensing CWH equipment is lower than that of non-condensing equipment, despite the comments from industry purporting this viewpoint. DOE does have and has incorporated data regarding increased repair costs for individual component failures that may occur in higher-efficiency equipment, as discussed in section IV.F.2.f of this document. DOE considered basing lifetime on warranty periods, but notes that warranty periods are based on individual business decisions for each manufacturer or entity that offers a warranty, decisions which likely reflect considerations other than expected lifetime. Accordingly, DOE has not used warranty periods to establish equipment lifetime in this NOPR. Additionally, DOE notes that lifetime used for hot water supply boilers in this proposed rulemaking is the same as the lifetime used in the space heating boilers rulemaking. (Docket No. EERE–2014–BT–STD–0030–0083 at p.8F–1)

h. Discount Rate

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

DOE applies weighted average discount rates calculated from consumer debt and asset data, rather than marginal or implicit discount rates.[101] DOE notes that the LCC does not analyze the appliance purchase decision, so the implicit discount rate is not relevant in this model. The LCC 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, the application of a marginal interest rate associated with an initial source of funds is inaccurate. Regardless of the method of purchase, consumers are expected to continue to rebalance their debt and asset holdings over the LCC analysis period, based on the restrictions consumers face in their debt payment requirements and the relative size of the interest rates available on debts and assets. DOE estimates the aggregate impact of this rebalancing using the historical distribution of debts and assets.

To estimate the WACC of CWH equipment purchasers, DOE used a sample of detailed business sub-sector statistics, drawn from the database of U.S. companies presented on the Damodaran Online website.[102] This database includes most of the publicly-traded companies in the United States. Using this database, Damodaran developed a historical series of sub-sector-level annual statistics for 100+ business sub-sectors. Using data for 1998–2019, inclusive, DOE developed sub-sector average WACC estimates, which were then assigned to aggregate categories. For commercial water heaters, the applicable aggregate categories include retail and service, property/real-estate investment trust (''REIT''), medical facilities, industrial,

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

[101] The implicit discount rate is inferred from a consumer purchase decision between two otherwise identical goods with different first cost and operating cost. It is the interest rate that equates the increment of first cost to the difference in net present value of lifetime operating cost, incorporating the influence of several factors: Transaction costs; risk premiums and response to uncertainty; time preferences; interest rates at which a consumer is able to borrow or lend.

[102] *Damodaran Online.* Damodaran financial data used for determining cost of capital. Available at *pages.stern.nyu.edu/~adamodar/.* Last accessed on February 16, 2021.

hotel, food service, office, education, and other. The WACC approach for determining discount rates accounts for the applicable tax rates for each category. DOE did not evaluate the marginal effects of increased costs, and, thus, depreciation due to more expensive equipment, on the overall tax status.

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

For most educational buildings and a portion of the office buildings occupied by public schools, universities, and State and local government agencies, DOE estimated the cost of capital based on a 40-year geometric mean of an index of long-term tax-exempt municipal bonds (>20 years).[103] [104] Federal office space was assumed to use the Federal bond rate, derived as the 40-year geometric average of long-term (>10 years) U.S. government securities.[105]

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

To establish residential discount rates for the LCC analysis, DOE identified all relevant household debt or asset classes in order to approximate a consumer's opportunity cost of funds related to appliance energy cost savings. It estimated the average percentage shares of the various types of debt and equity by household income group using data from the Federal Reserve Board's Survey of Consumer Finances (SCF) [106] for 1995, 1998, 2001, 2004, 2007, 2010, 2013, 2016, and 2019. Using the SCF and other sources, DOE developed a distribution of rates for each type of debt and asset by income group to represent the rates that may apply in the year in which amended standards would take effect. In the Crystal Ball™ analyses, when an LCC model selects a residential observation, the model selects an income group and then selects a discount rate from the distribution for that group. Chapter 8 of the NOPR TSD contains the detailed calculations related to discount rates.

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

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

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

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

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

Each building in the sample was then assigned a water heater efficiency sampled from the no-new-standards case efficiency distribution for the appropriate equipment class, shown in Table IV.22. DOE was not able to assign a CWH efficiency to a building in the no-new-standards case based on building characteristics, since CBECS 2012 and RECS 2009 did not provide enough information to distinguish installed water heaters disaggregated by efficiency. The efficiency of a CWH was assigned based on the forecasted efficiency distribution (which is constrained by the shipment and model data collected by DOE and submitted by AHRI) and accounts for consumers that are already purchasing efficient CWHs.

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

There are several market failures or barriers that affect energy decisions generally. Some of those that affect the commercial sector specifically are detailed below. However, more generally, there are several behavioral factors that can influence the purchasing decisions of complicated multi-attribute products, such as water heaters. For example, consumers (or decision makers in an organization) are highly influenced by choice architecture, defined as the framing of the decision, the surrounding circumstances of the purchase, the alternatives available, and how they're presented for any given choice scenario.[107] 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.[108] Thaler, who won the

[103] Federal Reserve Bank of St. Louis. *State and Local Bonds—Bond Buyer Go 20-Bond Municipal Bond Index.* Data available through 2015 at *research.stlouisfed.org/fred2/series/MSLB20/downloaddata?cid=32995.* Last accessed April 3, 2020.

[104] Bartel Associates, LLC. *Ba 2019–12–31 20 Year AA Municipal Bond Rates.* Averaged quarterly municipal bond rates to develop annual averages for 2016–2020. *bartel-associates.com/resources/select-gasb-67-68-discount-rate-indices.* Last accessed on February 18, 2021.

[105] Rate calculated with rolling 40-year data series for the years 1989–2020. Data source: U.S. Federal Reserve. Available at *www.federalreserve.gov/releases/h15/data.htm.* Last accessed on February 18, 2021.

[106] Board of Governors of the Federal Reserve System. *Survey of Consumer Finances.* Available at *www.federalreserve.gov/PUBS/oss/oss2/scfindex.html.*

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

[108] 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

Continued

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.[109] These characteristics describe almost all purchasing situations of appliances and equipment, including CWHs. The installation of a new or replacement CWH in a commercial building is a complex, technical decision involving many actors and is done very infrequently, as evidenced by the CWH mean lifetime of up to 25 years.[110] Additionally, it would take at multiple billing cycles for any impacts on operating costs to be fully apparent. Further, if the purchaser of the CWH is not the entity paying the energy costs (*e.g.,* a building owner and tenant), there may be little to no feedback on the purchase. These behavioral factors are in addition to the more specific market failures described as follows.

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

First, a recognized problem in commercial settings is the principal-agent problem, where the building owner (or building developer) selects the equipment and the tenant (or subsequent building owner) pays for energy costs.[111] [112] Indeed, a substantial fraction of commercial buildings with a CWH in the CBECS 2012 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 impact the choice of a CWH. 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.[113] 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.[114] Decision-making related to commercial buildings is highly complex and involves gathering information from and for a variety of different market actors. It is common to see conflicting goals across various actors within the same organization as well as information asymmetries between market actors in the energy efficiency context in commercial building construction.[115]

Second, the nature of the organizational structure and design can influence priorities for capital budgeting, resulting in choices that do not necessarily maximize profitability.[116] 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.[117] U.S. tax rules for commercial buildings may incentivize lower capital expenditures, since capital costs must be depreciated over many years, whereas operating costs can be fully deducted from taxable income or passed through directly to building tenants.[118]

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.[119]

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).

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

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

[111] 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.

[112] Blum, H. and Sathaye, J. (2010). ''Quantitative Analysis of the Principal-Agent Problem in Commercial Buildings in the U.S.: Focus on Central Space Heating and Cooling,'' Lawrence Berkeley National Laboratory, LBNL–3557E. (Available at: *escholarship.org/uc/item/6p1525mg*) (Last accessed January 20, 2022).

[113] 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).

[114] 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).

[115] International Energy Agency (IEA). (2007). Mind the Gap: Quantifying Principal-Agent Problems in Energy Efficiency. OECD Pub. (Available at: *www.iea.org/reports/mind-the-gap*) (Last accessed January 20, 2022).

[116] 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.

[117] 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.

[118] Lovins, A. (1992). Energy-Efficient Buildings: Institutional Barriers and Opportunities. (Available at: *rmi.org/insight/energy-efficient-buildings-institutional-barriers-and-opportunities/*) (Last accessed January 20, 2022).

[119] 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.

Asymmetric information in financial markets is particularly pronounced with regard to energy efficiency investments.[120] 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,[121] which can bias firms towards more certain or familiar options. This market failure results not because the returns from energy efficiency as an investment are inherently riskier, but because information about the risk itself tends not to be available in the same way it is for other types of investment, like stocks or bonds. In some cases energy efficiency is not a formal investment category 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.[122] 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).[123] 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.[124]

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 [125] and required payback periods of many firms are higher than the appropriate cost of capital for the investment.[126] 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.[127] 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.[128] 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,[129] supermarkets,[130] and the electric motor market.[131]

The existence of market failures in the commercial and industrial sectors is well supported by the economics literature and by a number of case studies. If DOE developed an efficiency distribution that assigned 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. DOE thus concludes such a distribution would not be representative of the CWH market. Further, even if a specific building/organization is not subject to the market failures above, the purchasing decision of CWH efficiency can be highly complex and influenced by a number of factors not captured by the building characteristics available in the CBECS or RECS samples. These factors can lead to building owners choosing a CWH efficiency that deviates from the efficiency predicted using only energy use or economic considerations such as life-cycle cost or payback period (as calculated using the information from CBECS 2012 or RECS 2009).

DOE notes that EIA's Annual Energy Outlook [132] (''AEO'') is another energy use model that implicitly includes market failures in the commercial sector. In particular, the commercial demand module [133] includes behavioral rules regarding capital purchases such that in replacement and retrofit decisions, there is a strong bias in favor of equipment of the same technology (*e.g.,* water heater efficiency) despite the potential economic benefit of choosing other technology options. Additionally, the module assumes a distribution of time preferences regarding current versus future expenditures. Approximately half of the total commercial floorspace is assigned one of the two highest time preference premiums. This translates into very high discount rates (and hurdle rates) and represents floorspace for which equipment with the lowest capital cost will almost always be purchased without consideration of operating costs. DOE's assumptions regarding market failures are therefore consistent

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.

[120] 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.

[121] Reed, J.H., Johnson, K., Riggert, J., and Oh, A. D. (2004). ''Who plays and who decides: The structure and operation of the commercial building market,'' U.S. Department of Energy Office of Building Technology, State and Community Programs. (Available at: *www1.eere.energy.gov/buildings/publications/pdfs/commercial_initiative/who_plays_who_decides.pdf*) (Last accessed January 20, 2022).

[122] Cooremans, C. (2012). ''Investment in energy efficiency: do the characteristics of investments matter? '' *Energy Efficiency,* 5(4), 497–518.

[123] Lovins 1992, op. cit. The Atmospheric Fund. (2017). Money on the table: Why investors miss out on the energy efficiency market. (Available at: *taf.ca/publications/money-table-investors-energy-efficiency-market/*) (Last accessed January 20, 2022).

[124] 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 April 6, 2022).

[125] 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.

[126] DeCanio 1994, op. cit.

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

[128] 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.

[129] 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.

[130] 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.

[131] de Almeida, E.L.F. (1998). ''Energy efficiency and the limits of market forces: The example of the electric motor market in France'', *Energy Policy,* 26(8), 643–653. Xenergy, Inc. (1998). United States Industrial Electric Motor Systems Market Opportunity Assessment. (Available at: *www.energy.gov/sites/default/files/2014/04/f15/mtrmkt.pdf*) (Last accessed January 20, 2022).

[132] EIA, Annual Energy Outlook, *www.eia.gov/outlooks/aeo/* (Last accessed January 25, 2022).

[133] For further details, see: *www.eia.gov/outlooks/aeo/assumptions/pdf/commercial.pdf* (Last accessed January 25, 2022).

with other prominent energy consumption models.

The estimated market shares for the no-new-standards case for CWH equipment are shown in Table IV.22. See chapter 8 of the NOPR TSD for further information on the derivation of the efficiency distributions.

TABLE IV.22—MARKET SHARES FOR THE NO-NEW-STANDARDS CASE BY EFFICIENCY LEVEL FOR CWH EQUIPMENT

EL	Commercial gas-fired storage water heaters (%)	Residential-duty gas-fired storage water heaters (%)	Gas-fired instantaneous tankless water heaters (%)	Gas-fired circulating water heaters and hot water supply boilers (%)
0	33.9	17.9	17.0	4.3
1	3.2	12.0	0.0	12.0
2	0.0	7.2	0.0	15.1
3	12.3	31.5	0.0	2.1
4	49.7	27.0	20.8	15.8
5	0.9	4.5	62.3	50.7

3. Payback Period

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

The inputs to the PBP calculation for each efficiency level are the change in total installed cost of the product and the change in the first-year annual operating expenditures relative to the baseline. The PBP calculation uses the same inputs as the LCC analysis, except that discount rates are not needed.

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 [134] by calculating the energy savings in accordance with the applicable DOE test procedure, and multiplying those savings by the average energy price projection for the year in which compliance with the amended standards would be required. Chapter 8 of the NOPR TSD provides additional details about the PBP.

G. Shipments Analysis

DOE uses projections of annual equipment shipments to calculate the national impacts of potential amended or new energy conservation standards on energy use, NPV, and future manufacturer cash flows.[135] The shipments model, discussed in section IV.G.5 of this NOPR, takes an accounting approach, tracking market shares of each equipment category and the vintage of units in the stock. Stock accounting uses equipment shipments as inputs to estimate the age distribution of in-service equipment stocks for all years. The age distribution of in-service equipment stocks is a key input to calculations of both the NES and NPV because operating costs for any year depend on the age distribution of the stock.

As part of the analysis, DOE examined the possibility of fuel switching. DOE recognizes that some cities and states are passing legislation to eliminate fossil fuel use in new building construction, while other states have made moves to ban electrification legislation. Additionally, section 433 of the Energy Independence and Security Act of 2007 (''EISA 2007'') amendments to the Energy Conservation and Production Act requires that fossil fuel generated energy consumption be reduced to zero (as compared to a 2003 baseline) by 2030 for new construction and major renovations of Federal buildings. Depending on whether these various fossil fuel bans or electrification mandates allow for the purchase of renewable energy credits to offset natural gas usage, such bans could potentially result in a decrease in projected shipments of gas-fired CWH equipment. For 2026, DOE estimates that shipments of CWH equipment to new construction that are the subject of this rulemaking will comprise approximately 20 percent of total shipments. New Federal government construction is approximately 2 percent of new commercial construction; therefore, it would be estimated to make up a very small percentage of these shipments. DOE's shipment projections do not adjust for the impacts of electrification laws and regulations explicitly, as DOE has no data with which to make such an adjustment. However, since DOE used regression techniques and historical shipments data for this NOPR analysis, as described in sections IV.G.1 and IV.G.2 of this document, some impact may be accounted for implicitly. Beyond this, DOE has no data with which to adjust shipments, and DOE has historically not speculated about legislation or its impacts. Section IV.H.2 discusses fuel switching in more detail.

1. Commercial Gas-Fired and Electric Storage Water Heaters

To develop the shipments model, DOE started with known information on shipments of commercial electric and gas-fired storage water heaters collected for the years 1994–2020 from the AHRI website,[136] and extended back to 1989 with data contained in a DOE rulemaking document published in 2000.[137] The historical shipments of commercial electric and gas-fired storage water heaters are summarized in Table IV.23 of this NOPR. Given that the estimated average useful lifetimes of these two types of equipment are 12 and 10 years, respectively, the historical

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

[135] DOE uses data on manufacturer shipments as a proxy for national sales, as aggregate data on sales are lacking. In general, one would expect a close correspondence between shipments and sales.

[136] Air Conditioning, Heating, and Refrigeration Institute. *Commercial Storage Water Heaters Historical Data.* Available at *www.ahrinet.org/site/494/Resources/Statistics/Historical-Data/Commercial-Storage-Water-Heaters-Historical-Data.* Last accessed May 17, 2021.

[137] U.S. Department of Energy. *Screening Analysis for EPACT-Covered Commercial HVAC and Water-Heating Equipment. Volume 1—Main Report.* 2000. EERE–2006–STD–0098–0015. Available at *www.regulations.gov/#!documentDetail;D=EERE-2006-STD-0098-0015.*

shipments provided a basis for the development of a multi-year series of stock values. Using the stock values, a saturation rate was determined by dividing equipment stock by building stock, and this saturation rate was combined with annual building stock additions to estimate the shipments to new construction. With these data elements, a yearly accounting model was developed for the historical period to identify shipments deriving from new construction and from replacements of existing equipment. The accounting model also identified consumer migration into or out of the storage water heater equipment classes by calculating the difference between new plus replacement shipments and the actual historical shipments.

TABLE IV.23—HISTORICAL SHIPMENTS OF COMMERCIAL GAS-FIRED AND ELECTRIC STORAGE WATER HEATERS

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

At the public meeting for the withdrawn NOPR, AHRI stated the shipment projections are based on the projections of building stock growth, but the commenter suggested that DOE should compare its assumptions to the historical data in CBECS 2012 to determine whether the trend in the proposal makes sense. (AHRI, NOPR Public Meeting Transcript, No. 20 at pp. 123–125) In written comments, AHRI restated its belief that the projection of shipments of gas-fired storage water heaters is too high when compared to the 25-year historical data set, suggesting that a more reasonable forecast of shipments might be a flat 85,000 units per year. AHRI also stated its opinion that something systematic seems to be happening, such that the stock accounting approach used in the withdrawn NOPR might not be serving DOE well and that DOE should investigate other methods such as using actual historical data trends. (AHRI, No. 40 at p. 15)

DOE agrees with AHRI that an alternative to the stock accounting method might better serve DOE's purposes. For this NOPR, DOE utilized regression techniques to develop the shipments forecast based on the assumption that shipments of gas-fired storage water heaters are a function of relative prices of natural gas and electricity, building stocks (*i.e.,* the replacement market), and building stock additions (the new market). DOE investigated the use of variables that lead (*e.g.,* building stock additions 1 or 2 years in the future) or lag (*e.g.,* relative prices experienced 1 year in the past). Using historical data for the years 1994–2020, DOE investigated multiple model specifications to find the best trade-off between model statistics and making the most use of historical data. The result was a model yielding a forecast of shipments that increases 0.5 percent per year from 2021–2055, reaching just under 113,700 units by 2055. See chapter 9 of the NOPR TSD for further details. The resulting growth rate for shipments is less than the underlying growth in building stocks (1.0 percent between 2021–2055), a result that makes sense to DOE when combined with the forecast of continuing low natural gas prices well into the future. In summary, consistent with AHRI's suggestion, DOE investigated an alternative forecasting method—and the alternative DOE chose uses an econometric model to project commercial gas-fired storage unit shipments. For this NOPR, DOE used an econometric model that: (1) Makes use of all of the historical shipments data collected for the withdrawn NOPR, (2) projects shipments with embedded shifts that will rise and fall based on relative fuel prices and building stock projections, and (3) eliminates the need for DOE to make assumptions and adjustments to the level of apparent shifts when the expected shipments derived in the stock accounting framework exceeds or falls short of the actual shipments discussed in the withdrawn NOPR.

For the withdrawn May 2016 NOPR and for this NOPR, no historical information was available that specifically identified shipments of gas-fired storage-type instantaneous water heaters. The AHRI online historical shipments data explicitly states residentially marketed equipment is excluded but does not explicitly state whether instantaneous storage equipment is included or excluded. Because of the similarities between the commercial storage gas water heaters and the gas-fired storage-type instantaneous water heaters, DOE has included both in downstream analyses in this NOPR. However, DOE recognizes that some or all of the storage-type instantaneous shipments may not be captured in the historical AHRI shipments data. The DOE shipments analysis is derived from AHRI historical shipments data and thus may underrepresent future shipments of gas-fired storage-type instantaneous water heaters.

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

For the withdrawn NOPR, no historical shipment information was available for residential-duty gas-fired storage water heaters, gas-fired tankless water heaters, or gas-fired hot water supply boilers. Therefore, the NOPR and the NOPR TSD presented DOE's analysis, which estimated both past shipments and forecasts of future shipments for residential-duty gas-fired storage water heaters, gas-fired tankless waters, or gas-fired hot water supply boilers. DOE explained its shipments forecast methodology in some detail in the withdrawn NOPR, and the Department also requested feedback on the approaches used, actual historical data, or both. 81 FR 34440, 34488–34490 (May 31, 2016).

AHRI stated that shipments of instantaneous water heaters are significantly higher, and shipments of hot water supply boilers are significantly lower than DOE's estimates presented as part of the withdrawn NOPR. While AHRI conceded that they do not track hot water supply boiler shipments, they offered their opinion that DOE's estimate of shipments was overstated by an order of magnitude. AHRI stated that hot water supply boilers are a subset of commercial packaged boilers with changes to make them suitable for potable water. (AHRI, No. 40 at p. 15) AHRI and the water heater manufacturers also collected and submitted efficiency distribution data for gas-fired instantaneous equipment to DOE. (AHRI, No. 40 at p. 10) AHRI provided data from manufacturers on instantaneous water heater shipments to DOE's contractors under a confidentiality agreement and indicated that the data include shipments of gas-fired instantaneous tankless and circulating water heating equipment. A.O. Smith's written comments stated that data were being provided which DOE interprets to be referring to the data being provided through AHRI. A.O. Smith urged DOE to use these data, arguing that doing so will improve the estimates of national energy savings and other critical items. (A.O. Smith, No. 39 at p. 3) A.O. Smith also singled out for reconsideration what it described as the erratic aggregate growth in DOE's forecasted total shipments, particularly the gas-fired instantaneous tankless water heaters. (A.O. Smith, No. 39 at p. 14) Bradford White called on DOE to revise the methodology used to estimate historical shipments for residential-duty gas-fired storage water heaters and hot water supply boilers. Bradford White stated its opinion that it was not fair to draw conclusions that the decline in commercial gas-fired storage unit shipments from 1994 to 2009 and that the resurgence of such shipments to 1994 levels by 2013 were related to or a result of increasing shipments of hot water supply boilers or residential-duty gas-fired storage water heaters. (Bradford White, No. 42 at p. 10)

DOE acknowledges the work of AHRI and water heater manufacturers in collecting and submitting instantaneous water heater shipment data. As suggested by A.O. Smith, DOE is using this information. For this NOPR, DOE developed an econometric model similar to that described for commercial gas-fired storage water heater shipments; DOE used the AHRI-provided data to estimate an equation relating commercial instantaneous shipments to building stock additions and commercial electricity prices.[138] Because the historical data did not provide sufficient detail to identify the percentages represented by tankless and circulating water heater shipments, DOE estimated that 50 percent of the shipments are instantaneous tankless shipments and the remainder are circulating water heaters. Because the actual information provided by AHRI is confidential and cannot be disclosed, the only information being made available in this NOPR is the econometric forecast made for use in the analysis.

Since the equipment that DOE has been calling hot water supply boilers includes what AHRI calls circulators as well as a second type of equipment AHRI calls boilers, DOE clarifies that the new DOE forecast for hot water supply boilers includes both circulating water heating equipment and hot water supply boilers. The circulating water heater shipments were developed as described earlier. As noted in this shipments discussion, the withdrawn NOPR requested shipments data or information for projecting the number of hot water supply boilers. AHRI was the only stakeholder who responded to DOE's request for input related to shipments of hot water supply boilers. AHRI opined that the withdrawn NOPR forecast was an order of magnitude too high, and that hot water supply boilers are a subset of commercial packaged boilers with changes in headers and other factors that make them suitable for providing potable water. (AHRI, No. 40, p. 15) DOE clarifies that hot water supply boilers are considered ''packaged boilers'' within DOE's regulations, but are regulated as CWH equipment and do not meet DOE's definition of ''commercial packaged boiler,'' which specifically excludes hot water supply boilers.[139] However, DOE acknowledges the similarities in design between hot water supply boilers and commercial packaged boilers. DOE notes that AHRI offered their opinion that the hot water supply boiler shipment value was too high by a factor of 10 (an order of magnitude) in the context of having just collected shipments data on commercial gas-fired instantaneous water heaters and recently collected similar data on commercial packaged boilers. While AHRI provided an opinion as to the appropriateness of the hot water supply boiler shipment values used by DOE, this opinion is in the context of the collection of significant amounts of related data as indicated by AHRI. For this reason, DOE utilized AHRI's input to create a 2013 shipments estimate for hot water supply boilers by dividing the NOPR value for 2013 by 10. DOE then used the historical and forecasted growth rates in shipments of commercial small gas-fired packaged boilers to estimate historical and forecasted shipments of hot water supply boilers. This approach addresses the comments and information supplied by AHRI; it unlinks the hot water supply boiler forecast from the forecast of commercial gas-fired storage water heaters as suggested by Bradford White; it results in a smoother, less erratic forecast than the NOPR forecast that A.O. Smith asked DOE to reconsider; and it breaks the equivalency between hot water supply boilers and gas-fired commercial storage equipment types to which Spire objected. The hot water supply boiler shipments were combined with the aforementioned and described forecast of circulating water heater shipments to generate a forecast for the instantaneous products referred to in this notice as circulating water heaters and hot water supply boilers.

DOE was not able to identify additional information sources for residential-duty gas-fired shipments. DOE clarifies that residential-duty gas-fired storage water heaters are not residential water heaters. Instead, they are a type of CWH equipment and DOE draws no conclusions about residential-duty gas-fired storage shipments replacing or being replaced by commercial gas-fired storage water heater shipments. Rather, the linkage used in the DOE model would essentially have shipments of both types of storage equipment going up or down in parallel. DOE retained the forecasting method used for the withdrawn NOPR. To maintain a shipments forecast that is roughly consistent in magnitude with the NOPR forecast, DOE used the same 20 percent factor used for the NOPR. In other words, DOE assumes residential-duty gas-fired storage water heater shipments track with commercial gas-fired storage water heaters, and shipments of the former are assumed to be 20 percent of the shipments of the latter.

Issue 5: DOE seeks input on actual historical shipments for residential-duty gas-fired storage water heaters, gas-fired storage-type instantaneous water heaters, and for hot water supply boilers.

Issue 6: DOE seeks additional actual historical shipment information for commercial gas-fired instantaneous tankless water heaters covering the period between 2015 and 2020 to supplement the data provided in response to the withdrawn NOPR.

See section VII.E of this document for a list of issues on which DOE seeks comment.

3. Available Products Database and Equipment Efficiency Trends

In response to the withdrawn NOPR, AHRI, Bradford White, and Raypak objected to the use of the number of models listed in the AHRI directory as representative of the number of shipments by efficiency level. Bradford White, A.O. Smith, and Raypak stated

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

[139] *See* 10 CFR 431.82. Hot water supply boiler is defined at 10 CFR 431.102.

that DOE should rely instead on the shipments data collected and provided by AHRI. (AHRI, No. 40 at p. 13; Bradford White, No. 42 at pp. 2–3; A.O. Smith, No. 39 at p. 3; Raypak, No. 41 at p. 5) Raypak further stated that DOE should have looked for alternative ways to fill in this information, and offered its opinion that DOE personnel are aware that the number of units listed in the AHRI directory do not correlate to shipments. (Raypak, No. 41 at p. 5) Bradford White provided examples of how counting models in the database may lead to inaccurate results and stated that sales of the older models listed in the AHRI database tend to decline over time. (Bradford White, No. 42 at p. 14) Rheem also disputed DOE's methodology to estimate historical shipments for all equipment classes, stating the number of certified models is inadequate for determining the number of shipments. (Rheem, No. 43 at p. 26) AHRI argued that available models are a lagging indicator, and similar to the Bradford White comment, stated that shipments of older models tend to decline as new units are introduced into the market. AHRI added that when DOE uses available models, it needs to find a methodology to adjust share to account for underlying growth in high-efficiency products. (AHRI, No. 40 at p. 13)

Several stakeholders asserted that the assumption used for the analysis in the withdrawn NOPR of constant equipment efficiency over time was incorrect. PHCC commented that market evidence indicates growth in energy-efficient product uptake without new standards, pointing to manufacturers increasing their product offerings due to competitive pressures to differentiate themselves from competitors. (PHCC, No. 34 at p. 1) AHRI commented that the percentage of condensing products actually shipped is much higher than DOE projected in its analysis, and to support its point, the trade association provided historical data on the share of shipments represented by condensing equipment for commercial gas-fired storage and instantaneous products. (AHRI, No. 40 at pp. 10–13) AHRI recommended that DOE recalculate the NIA in order to ensure national energy savings reflect the market-driven savings from the purchases of condensing equipment in the absence of such standards and as reflected in shipments-by-efficiency bin data provided. (AHRI, No. 40 at p. 14) Bock, A.O. Smith, and Spire pointed to AHRI's comments as evidence of the growth in equipment efficiency over the course of the currently effective standard, which they argue is occurring in absence of new standards. (Bock, No. 33 at p. 2; A.O. Smith, No. 39 at p. 5; Spire, No. 45 at p. 14) A.O. Smith added that its company sales data demonstrate annual growth of higher-efficiency CWH equipment and urged DOE to reconcile its data set with the data compiled by AHRI. (A.O. Smith, No. 39 at p. 5) Rheem believes DOE's assumption of no growth in equipment efficiency is flawed based on an incorrect premise that the number of available models by efficiency level is directly proportional to the market penetration. Rheem added there is a much higher shipment rate of higher-efficiency CWH models by Rheem than the proportional number of higher-efficiency certified models, and that shipments of high-efficiency CWH equipment are increasing steadily and disproportionately to the number of certified models. (Rheem, No. 43 at pp. 7, 25)

DOE acknowledges the efforts of AHRI and the water heater manufacturers in collecting and providing efficiency distribution data for commercial gas-fired storage water heater and for instantaneous gas-fired water heater shipments. DOE also acknowledges the anecdotal evidence provided by A.O. Smith and Rheem about shipments of efficient models. DOE, as suggested by AHRI, revised the shipments and other analyses to reflect this information. Thus, in response to the suggestions of A.O. Smith, Rheem, and others, DOE did reconcile the analyses to account for the AHRI data rather than relying heavily on the number of available models. In response to the parties that objected to the analyses not showing an increasing efficiency trend, DOE's NOPR analyses do now show such a trend.

To the extent that there may be concerns about data availability, DOE notes that analyses are based to the largest extent possible on actual data. The available model database provided actual data illustrating a point in time, and DOE did not possess actual data from other points in time to provide evidence of a trend. While manufacturers may provide data during manufacturer interviews, such information is subject to non-disclosure agreements and is typically manufacturer-specific. It can become available for use in analyses such as the shipments analysis when sufficient data points are collected from multiple parties to enable the interview team to mask an individual party's data sufficiently; the use of the data provided by AHRI allows for inclusion of actual data at an aggregate level.

With respect to potential concerns about the impact of federal, state, and local building energy codes on shipments of CWH equipment, DOE notes that under EPCA, State building codes are generally prohibited from requiring standards for CWH equipment that require energy efficiency levels more stringent than the applicable minimum energy efficiency requirement in the amended ASHRAE 90.1. (42 U.S.C. 6316(b)(2)(A) & (B))

Similarly, DOE also recognizes that there are businesses, government entities, educational institutions, health care facilities, and other institutional purchasers of CWH equipment that are already adopting environmental, sustainability, or climate plans in which they seek reduction in energy consumption and carbon emissions. These factors indicate a sizable share of the market will be purchasing efficient equipment. DOE notes that the ENERGY STAR CWH criteria became effective in March 2013, and a comparison of the first 2 years of ENERGY STAR results mirror the efficiency distribution data provided by AHRI and the water heater manufacturers. Additionally, Federal buildings are subject to Federal Energy Management Program (''FEMP'') purchasing requirements, and have been required to purchase condensing equipment since 2012. Currently, the FEMP requirement is to purchase ENERGY STAR-qualifying equipment or FEMP-designated equipment for commercial gas-fired storage and instantaneous tankless gas-fired commercial water heaters.[140] In summary, DOE has tentatively concluded that these shipments are likely already reflected in the AHRI shipment statistics, which have been used to update DOE's analyses for this NOPR, and therefore no further adjustments are necessary.

To the extent that there are concerns about the length of the analysis period, DOE recognizes that a 30-year study period is a long time, and much can happen in 30 years that would affect the results, but notes that this rulemaking includes circulating water heaters and hot water supply boilers with 25-year expected lives; therefore, a study period less than 30 years might not even cover the lifetime of the longest-lived piece of equipment shipped. DOE acknowledges that in the future, more-stringent efficiency standards are possibilities. However, the energy savings and other benefits accruing from standards set by

[140] 42 U.S.C. 8259b; 10 CFR part 436, subpart C. For FEMP requirements for commercial gas-fired water heaters see the FEMP web page: *energy.gov/eere/femp/purchasing-energy-efficient-commercial-gas-water-heaters.*

this rulemaking are analyzed and attributed to this standard. In future standards analyses, the standards set by this proposed rulemaking become part of the baseline.

Issue 7: DOE seeks historical shipments data dividing shipments between condensing and non-condensing efficiencies, for all product types that comprise the subject of this proposed rulemaking.

4. Shipments to Residential Consumers

DOE determined the fractions of commercial and residential applications for each equipment category based on the number of samples (in both CBECS and RECS) selected as relevant to be served by each equipment category considered in this rulemaking. With regard to what types of residential building starts are relevant to forecasting commercial equipment shipments, in response to the withdrawn NOPR, Bradford White stated that multi-family buildings are the only building stock where CWH shipments would be appropriate. Bradford White believes shipments of commercial water heaters to single-family homes are minimal, though the commenter has heard of some such use in really large single-family houses. (Bradford White, No. 42 at p. 10) Rheem's input was similar, with the additional detail that single-family homes greater than 5,000 square feet are more likely to use commercial water heaters. (Rheem, No. 43 at p. 27) A.O. Smith stated that in its experience, multi-family buildings were the only residential application for commercial water heaters. (A.O. Smith, No. 39 at p. 16) Based upon these comments, for this NOPR, DOE did not include residential single-family building stock growth and used only residential multi-family building stocks and building additions when considering the potential non-commercial consumer component in the development of the shipments forecasts.

5. NOPR Shipments Model

To project shipments and equipment stocks for 2021 through the end of the 30-year analysis period (2055), DOE used the shipments forecasting models (described in sections IV.G.1 and IV.G.2 of this NOPR) and a stock accounting model. For each class of equipment, DOE forecasted shipments exogenously as described in the response to comments. The stock accounting model keeps track of shipments and calculates replacement shipments based on the historical shipments, the expected useful lifetime of each equipment class, and a Weibull distribution that identifies a percentage of units still in existence from a prior year that will fail and need to be replaced in the current year. In each year, DOE assumed a fraction of the replacement market will be retired rather than replaced due to the demolition of buildings in which this CWH equipment resides. This retirement fraction was derived from building stock data from the *AEO2021*.[141]

To project shipments of CWH equipment for new construction, DOE relied on building stock data obtained from *AEO2021*. For this NOPR, DOE assumes CWH equipment is used in both commercial buildings and residential multi-family buildings. DOE estimated a saturation rate for each equipment type using building and equipment stock values. The saturation rate was applied to new building additions in each year, yielding shipments to new buildings. The building stock and additions projections from *AEO2021* are shown in Table IV.24.

TABLE IV.24—BUILDING STOCK PROJECTIONS

Year	Total commercial building stock (million sq. ft.)	Commercial building stock additions (million sq. ft.)	Multi-family residential building stock (millions of units)	Multi-family residential building additions (millions of units)
2021	92,494	2,015	32.23	0.42
2025	96,109	2,110	33.22	0.42
2026	97,087	2,117	33.47	0.42
2030	100,970	2,155	34.40	0.40
2035	106,060	2,277	35.46	0.38
2040	111,151	2,307	36.45	0.38
2045	116,359	2,418	37.45	0.39
2050	121,825	2,520	38.44	0.39
2055*	127,540	2,633	39.48	0.41

Source: EIA *AEO2021 Reference case.*
* Post-2050, the projections were extended using the average annual growth rate from 2040 to 2050.

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

Based on the historic data, there is an apparent shift toward electric storage water heating equipment. The historical shipments summarized in Table IV.23 of this document show a steady growth in commercial electric storage water

[141] U.S. Energy Information Administration (EIA). *2021 Annual Energy Outlook.* January 2021. Available at *www.eia.gov/forecasts/aeo/.*

heaters, with shipments growing from 22,288 in 1994 to 150,665 in 2019. Over the same time period, commercial gas-fired storage water heaters have seen a decline in shipments from 91,027 in 1994 to a low of 75,487 in 2009. After 2009, gas-fired storage water heater shipments rebounded, reaching a shipment level of 88,548 in 2019 (and a peak of 98,095 in 2015). During the period 2009 through 2015, there was a reduction in the apparent shift away from commercial gas-fired storage units compared to the earlier period; however, there appeared to be an increase in 2016–2017 before returning to a reduction in the shift in commercial gas-fired storage units. Because the forecasted shipments of residential-duty gas-fired storage water heaters are linked to commercial gas-fired storage units, there is a similar shift away from the residential-duty gas-fired storage equipment class in the shipment forecast. Gas-fired instantaneous equipment appears to have a positive shift pattern.

Because the commercial gas-fired storage and gas-fired instantaneous CWH shipments forecasts were developed using econometric models based on historical data, these apparent shifts are captured in DOE's shipments model and embedded in the total forecast. For purposes of assigning equipment costs and energy usage in the NIA, DOE needs to know if the increased/decreased shipments are new or replacement shipments. For all equipment classes, DOE assumed that the apparent shift is most likely to occur in new installations rather than in the replacement installations. As described in chapter 9 of this NOPR TSD, DOE assumed that a shift is twice as likely to take place in a new installation as in a replacement installation. For example, if DOE estimated that in 2021, 20 percent of shipments for an equipment class went to new installations and 80 percent went for replacements in the absence of switching, DOE multiplied the 20 percent by 2 (40 percent) and added the 80 percent (which equals 120 percent). Both the 40 percent for new and the 80 percent for replacement were then divided by 120 percent to normalize to 100 percent, yielding revised shipment allocations of 33 percent for new and 67 percent for replacement.

The resulting shipment projection is shown in Table IV.25.

TABLE IV.25—SHIPMENTS OF COMMERCIAL WATER HEATING EQUIPMENT

Year	Commercial gas-fired storage water heaters and gas-fired storage-type instantaneous water heaters (units)	Residential-duty gas-fired storage water heaters (units)	Gas-fired tankless water heaters (units)	Gas-fired circulating water heaters and hot water supply boilers (units)
2021	97,418	19,484	8,708	10,484
2025	98,366	19,673	10,834	12,705
2026	99,373	19,875	11,297	13,236
2030	101,160	20,232	13,146	15,232
2035	103,099	20,620	15,469	17,695
2040	105,765	21,153	17,441	19,620
2045	108,590	21,718	19,712	21,964
2050	111,381	22,276	21,916	24,277
2055	113,671	22,734	24,323	26,797

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

Because the estimated energy usage of CWH equipment differs by commercial and residential settings, the NIA employs the same fractions of shipments (or sales) to commercial and to residential consumers used by the LCC analysis. The fractions of shipments by type of consumer are shown in Table IV.26.

TABLE IV.26—SHIPMENT SHARES BY TYPE OF CONSUMER

Equipment	Commercial	Residential
Commercial gas-fired storage water heaters and gas-fired storage-type instantaneous water heaters	79%	21%
Residential-duty gas-fired storage water heaters	56	44
Gas-fired instantaneous water heaters and hot water supply boilers:		
Gas-fired tankless water heaters	69	31
Gas-fired circulating water heaters and hot water supply boilers	79	21

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

H. National Impact Analysis

The NIA assesses the NES and the NPV from a national perspective of total consumer costs and savings that would be expected to result from amended standards at specific efficiency levels.[142] (''Consumer'' in this context refers to consumers of the equipment being regulated.) DOE calculates the NES and NPV for the potential standard levels considered based on projections of annual equipment shipments, along with the annual energy consumption and total installed cost data from the energy use and LCC analyses. For this NOPR analysis, DOE projected the energy savings, operating cost savings, equipment costs, and NPV of consumer benefits for equipment shipped from 2026 through 2055, the year in which the last standards-compliant equipment would be shipped during the 30-year analysis period.

DOE evaluates the impacts of amended standards by comparing a case without such standards with standards-case projections. The no-new-standards-case characterizes energy use and consumer costs for each equipment class in the absence of any new or amended energy conservation standards. For this projection, DOE considers historical trends in efficiency and various forces that are likely to affect the mix of efficiencies over time. DOE compares the no-new-standards-case with projections characterizing the market for each equipment class if DOE adopted new or amended standards at specific energy efficiency levels (*i.e.,* the TSLs or standards cases) for that class. For the standards cases, DOE considers how a given standard would likely affect the market shares of equipment with efficiencies greater than the standard.

DOE uses a spreadsheet model to calculate the energy savings and the national consumer costs and savings from each TSL. Chapter 10 and appendix 10A of the NOPR TSD explains the model and how to use it. The model and documentation are available on DOE's website.[143] Interested parties can review DOE's analyses by changing various input quantities within the spreadsheet.

Unlike the LCC analysis, the NIA does not use distributions for inputs or outputs, but relies on inputs based on national average equipment costs and energy costs. DOE used the NIA spreadsheet to perform calculations of NES and NPV using the annual energy consumption, maintenance and repair costs, and total installed cost data from the LCC analysis. The NIA also uses energy prices and building stock and additions consistent with the projections from the *AEO2021.* NIA results are presented in chapter 10 of the NOPR TSD.

Table IV.27 summarizes the inputs and methods DOE used for the NIA analysis for this NOPR. Discussion of these inputs and methods follows the table. See chapter 10 of the NOPR TSD for further details.

TABLE IV.27—SUMMARY OF INPUTS AND METHODS FOR THE NATIONAL IMPACT ANALYSIS

Inputs	Method
Shipments	Annual shipments from shipments model.
Compliance Date of Standard	2026.
Efficiency Trends	No-new-standards case, standards cases.
Annual Energy Consumption per Unit	Annual weighted-average values are a function of energy use at each TSL.
Total Installed Cost per Unit	Annual weighted-average values are a function of cost at each TSL.
Annual Energy Cost per Unit	Annual weighted-average values as a function of the annual energy consumption per unit and energy prices.
Repair and Maintenance Cost per Unit	Annual values do not change with efficiency level.
Energy Price Trends	*AEO2021* projections (to 2050) and extrapolation thereafter.
Energy Site-to-Primary and FFC Conversion	A time-series conversion factor based on *AEO2021.*
Discount Rate	3 percent and 7 percent.
Present Year	2021.

1. Equipment Efficiency Trends

A key component of the NIA is the trend in energy efficiency projected for the no-new-standards case and each of the standards cases. DOE uses a no-new-standards-case distribution of efficiency levels to project what the CWH equipment market would look like in the absence of potential standards. For the withdrawn NOPR, DOE developed the no-new-standards-case distribution of equipment by thermal efficiency levels, and by standby loss efficiency levels, for CWH equipment by analyzing a database[144] of equipment currently available. For the standards cases, DOE used a ''roll-up'' scenario to establish the shipment-weighted efficiency for the year that standards are assumed to become effective (2026). In this scenario, the market shares of equipment in the no-new-standards case that do not meet the standard under consideration would ''roll up'' to meet the new standard level, and the market share of equipment above the standard would remain unchanged. The approach is further described in chapter 10 of the NOPR TSD.

In comments filed in response to the withdrawn NOPR, Spire criticized a random selection of standards-case efficiencies as leading to inaccurate forecasts of cost and energy savings. (Spire, No. 45 at pp. 24, 25) Spire also commented on the issue of consumers switching to more-efficient equipment regardless of regulatory standards. (Spire, No. 45 at pp. 25, 32, 33) AHRI

[142] The NIA accounts for impacts in the 50 states and the District of Columbia.

[143] DOE's web page on commercial water heating equipment is available at *www1.eere.energy.gov/buildings/appliance_standards/standards.aspx?productid=36.*

[144] This database was developed using model data from DOE's Compliance Certification database (available at *www.regulations.doe.gov/certification-data/*) and manufacturer websites and catalogs.

also brought up the issue of whether consumers would migrate to condensing options due to economic reasons, even without amended minimum energy efficiency standards. (AHRI, NOPR Public Meeting Transcript, No. 20 at pp. 104, 105)

In response to Spire's comments, DOE notes it constructed the no-new-standards efficiency distribution using its database as discussed in section IV.A.3. of this document. The selections in the LCC model, while random, are based on the distributions created from the best available data. The issue of the random assignment of equipment in the no-new standards case is discussed specifically in section IV.F.2.i. DOE uses this distribution in the LCC to model consumer choices that mirror the market and uses the mean values from the LCC analysis in the NIA. DOE stated at the NOPR public meeting that if data such as that provided by AHRI were available, the forecast of consumer costs and savings would be improved. (DOE, Public Meeting Transcript, No. 20, p. 21) At the public meeting, DOE also stated that if manufacturers provide shipment data, DOE would use it in the analysis, and DOE has made use of the data provided by AHRI. DOE agrees with Spire's and AHRI's contention that some consumers will purchase higher-efficiency equipment even in the absence of amended standards. Consequently, for this NOPR, DOE developed the no-new-standards distribution of equipment by thermal efficiency levels for CWH equipment using data from DOE's Compliance Certification database and data submitted by AHRI regarding condensing versus non-condensing equipment. Using the data provided by AHRI, DOE has modeled a no-new-standards efficiency trend in which 75 to 85 percent of consumers purchase condensing equipment by 2055 by using the historical AHRI data to develop a future trend, but the Department points out that at present, the adoption of equipment equivalent to the standards proposed herein is currently less than half of total shipments.[145] Thus, this NOPR analysis assigns substantial credit to market-driven efficiency accomplishments. DOE further notes that new and replacement markets were modeled using the same efficiency distributions.

The shipments analysis section of this NOPR addresses comments received from stakeholders related to DOE's withdrawn NOPR shipment forecast that included constant equipment efficiency based on the available equipment database (see section IV.G.3). In comments about the NIA, Bock, A.O. Smith, Spire, and AHRI all reiterated their shipments comments concerning their belief that market shares by thermal efficiency derived from the available equipment database differ from the distribution that would be derived from actual shipments. The same stakeholders referenced data collected by AHRI, and stated that the sale of condensing gas-fired storage and/or instantaneous tankless gas-fired water heaters is higher than DOE assumed in the withdrawn NOPR, and called on DOE to use the shipments data provided by AHRI in the calculation of energy savings. AHRI and Bock highlighted the level of the condensing unit sales, with AHRI noting the market share was approaching 46 percent of total shipments in 2015 and with Bock arguing that given historical growth rates, the market share would be expected to achieve majority market share by 2020. Spire stated that DOE overestimated NOPR energy savings by using an efficiency distribution that underrepresents high-efficiency equipment, thereby stripping market-driven efficiency gains from the no-new-standards case and attributing these efficiency gains to the proposed standards. (Bock, No. 33 at p. 1; A.O. Smith, No. 39 at pp. 14–15; Spire, No. 45 at p. 14; AHRI, No. 40 at p. 10)

For this NOPR, DOE used the AHRI efficiency data to fit a Bass Diffusion curve, which shows continued market-driven efficiency improvements over the forecast period up to a point where 75 percent of commercial and residential-duty gas-fired storage and circulating water heaters and hot water supply boiler shipments are condensing in the no-new-standards case. For instantaneous tankless shipments, DOE modeled up to 85 percent of shipments in the condensing efficiency levels because it appears that presently, the percentage is much higher than for the other equipment types. Thus, an increasing efficiency trend is now modeled over the 30-year analysis period in the NIA model. While numerous other changes to the engineering, installation costs, and energy use analyses prevent direct comparisons in terms of varying only the efficiency distribution, the NOPR national energy savings and net present value of consumer benefits for the TSLs evaluated are reduced because a significant percentage of both are now attributed to market forces.

Bradford White cautioned that DOE should understand that AHRI data do not capture the entire industry, but only reporting members. (Bradford White, NOPR Public Meeting Transcript, No. 20 at p. 112) With respect to the shipments information provided by AHRI and manufacturers, DOE considers the data to be a significant improvement over the data available for the May 2016 CWH ESC NOPR phase. DOE uses the data with the caution, as it does with any data, and DOE does make adjustments when information becomes available to enable DOE to improve the quality of such data.

Table IV.28 shows the starting distribution of equipment by efficiency level. In the no-new-standards case, the distributions represent the starting point for analyzing potential energy savings and cumulative consumer impacts of potential standards for each equipment category.

TABLE IV.28—MARKET SHARES BY EFFICIENCY LEVEL IN 2026 *

Equipment	EL 0 ** (%)	EL1 (%)	EL2 (%)	EL3 (%)	EL4 (%)	EL5 (%)
Commercial gas-fired storage water heaters and gas-fired storage-type instantaneous water heaters	34	3	0	12	50	1
Residential-duty gas-fired storage water heaters	18	12	7	31	27	4
Gas-fired instantaneous water heaters and hot water supply boilers:						

[145] U.S. EPA. ENERGY STAR Unit Shipment and Market Penetration Report Calendar Year 2019 Summary. Available at *www.energystar.gov/sites/default/files/asset/document/2019%20Unit%20Shipment%20Data%20Summary%20Report.pdf* (last accessed July 7, 2021).

TABLE IV.28—MARKET SHARES BY EFFICIENCY LEVEL IN 2026 *—Continued

Equipment	EL 0 ** (%)	EL1 (%)	EL2 (%)	EL3 (%)	EL4 (%)	EL5 (%)
Gas-fired tankless water heaters	17	0	0	0	21	62
Gas-fired circulating water heaters and hot water supply boilers	4	12	15	2	16	51

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

For each efficiency level analyzed, DOE used a ''roll-up'' scenario to establish the market shares by efficiency level for the year that compliance would be required with potential standards. The analysis starts with the no-new-standards-case distributions wherein shipments are assumed to be distributed across efficiency levels as shown in Table IV.28. When potential standard levels above the base level are analyzed, as the name implies, the shipments in the no-new-standards case that did not meet the efficiency standard level being considered would roll up to meet the next higher standard level. The ''roll-up'' scenario also suggests that equipment efficiencies in the no-new-standards case that were above the standard level under consideration would not be affected. The no-new-standards-case efficiency distributions for each equipment class are discussed more fully in chapter 10 of the NOPR TSD. The no-new-standards-case efficiency distributions for each equipment category are discussed more fully in chapter 10 of the NOPR TSD.

2. Fuel and Technology Switching

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

DOE conducted a high-level analysis by using average NIA inputs and equipment operating hour data from the energy analysis to examine consumer PBPs in situations where they might switch from gas-fired to electric water heaters in both new and replacement construction at the proposed standard level. As previously noted, DOE is not analyzing thermal efficiency standards for electric storage water heaters since the thermal efficiency of these units already approaches 100 percent; as such, the underlying technology has most likely not changed, so for comparison purposes in this NOPR, the installation, equipment, and maintenance and repair costs from the withdrawn 2016 NOPR have been adjusted to account for inflation.[146] To make the costs comparable across equipment categories, DOE adjusted the average costs using ratios based on the first-hour ratings shown in Table IV.29.

TABLE IV.29—FIRST-HOUR EQUIPMENT RATINGS USED IN THE FUEL SWITCHING ANALYSIS

Year	Commercial gas-fired storage water heaters	Residential-duty gas-fired storage water heaters	Gas-fired tankless water heaters	Gas-fired circulating water heaters and hot water supply boilers	Electric storage water heaters
First-Hour Rating (gal)	283	134	268	664	165
Ratio to Commercial Gas-fired Storage	1.00	0.47	* 0.32	2.34	0.58

* The ratio of the number of installed commercial gas-fired storage water heaters to installed gas-fired tankless water heaters is not directly comparable using only first-hour ratings, here based on a 90 °F temperature rise. The ratio shown reflects in-use delivery capability of the representative gas-fired tankless water heater model relative to the delivery capability of the representative commercial gas-fired storage water heater, and includes an estimated 3-to-1 delivery capability tradeoff for a tankless unit without storage compared to the representative gas-storage water heater with the same first-hour rating.

DOE reviewed the installed cost of commercial electric and gas-fired storage water heaters, both at the no-new-standards-case efficiency level and with the standard level proposed herein for commercial gas-fired water heaters. The analysis uses costs for the year 2026, the first year that an amended standard would be in effect. In new installations, the analysis assumes that the inflation-adjusted commercial electric storage water heater installed cost is $4,205 and the first year maintenance and repair cost is $48.[147] In replacement installations, the analysis assumes that the inflation-adjusted commercial electric storage water heater installed cost is $3,950 and the first year maintenance and repair cost is $48. In further investigating the potential for fuel-switching, DOE first scaled the first costs and the maintenance and repair costs of the electric storage water in new and replacement installations linearly with first-hour rating assuming that the consumer needs to meet the first hour capacity of the representative commercial gas-fired storage water heater. To better compare the electric energy use in a fuel switching scenario, DOE examined the average burner operating hours for the commercial gas water heater to meet the hot water load, as detailed in appendix 7B of the NOPR TSD. By multiplying the input rating of the gas storage water heater by the baseline thermal efficiency and the average 2.60 hour of operation to meet

[146] Electric storage water heater costs were escalated from 2014$ to 2020$ using gross domestic product price deflators. First year electricity costs were recalculated using the *AEO2021* prices for 2026, weighted by the percent of shipments to the commercial and residential markets for the comparison equipment class (commercial gas-fired or residential-duty).

[147] Since the electric storage water heater was dropped from this NOPR, for this analysis the MPC from the withdrawn 2016 ECS NOPR standby loss level 0 was used to represent no-new-standards-case electric storage water heaters.

the water load including piping losses (and not included standby burner operation), the average daily hot water provided by the unit was estimated at 413,920 Btu/day. Assuming a 100% conversion efficiency for the electric energy to provide this load would be would 121.31 kWh/day or 44,279 kWh/yr with an energy cost of $4,852 in the first year. DOE notes that this value does not account for additional energy for electric water heater standby losses.

With the electric water heater costs thus scaled and corresponding energy cost calculated, within new construction installations the commercial gas storage water heater was estimated to be slightly more expensive to purchase and install than the electric storage unit in both the no-new-standards and standards cases, but significantly less costly to operate (see Table IV.30). In these cases, the up-front cost premium of the commercial gas-fired storage unit at the proposed standard level (TSL 3) relative to the scaled electric storage unit costs, divided by the annual operating savings for choosing the gas water heater, yields a PBP of 0.18 years, compared to a PBP of 0.15 years in the no-new-standards case. In replacement markets, the total installed cost of a commercial gas-fired storage unit was compared to the first-hour-rating scaled cost estimate for the commercial electric water heater as a replacement unit from the withdrawn 2016 NOPR. The estimated total installed cost of the comparable electric storage unit exceeds the cost of the commercial gas-fired storage unit. As with new construction, the replacement electric storage unit is substantially more costly to operate.

TABLE IV.30—TYPICAL UNIT COSTS, SCALED FOR FIRST-HOUR RATING (COMMERCIAL GAS-FIRED STORAGE = 1.0)—ELECTRIC STORAGE VERSUS COMMERCIAL GAS-FIRED STORAGE

[2020$]

Equipment	Cost	No-new-standards case new construction	No-new-standards case replacement *	Standards case new construction	Standards case replacement *
Electric Storage	Installed Cost	$7,212	$6,774	$7,212	$6,774
	Energy, Maintenance, and Repair Cost (First Year).	4,935	4,935	4,935	4,935
Commercial Gas-fired Storage	Installed Cost	7,645	4,723	7,789	6,056
	Energy, Maintenance, and Repair Cost (First Year).	1,963	1,961	1,733	1,727

* Installed costs for electric storage water heaters shown for the replacement case do not include cost of infrastructure alterations (*e.g.,* upgraded wiring, removal or modification of gas infrastructure).

DOE further notes that, depending on the specifics of the commercial building, significant additional costs could be incurred in switching to electric storage water heaters if the existing building lacks the electrical wiring and related infrastructure to handle the input rating of a scaled capacity commercial electric water heater. Thus, DOE has tentatively concluded that the proposed standard will not cause a noticeable increase in fuel switching from commercial gas-fired to electric storage water heaters.

A similar analysis to that of the commercial gas storage water heater and electric equivalent was repeated separately for residential-duty water heaters. The first costs and maintenance and repair costs were scaled by first hour rating to that equivalent to the representative residential-duty water heater. The hot water load for the electric equivalent unit was estimated based on the burner operating hours from Appendix 7B of the TSD and the electric water heater energy costs were estimated assume 100% conversion efficiency of the electric input to hot water load. For an electric water heater equivalent to a residential-duty gas water heater, the estimated energy consumption was 19,492 kWh/yr, equating to an energy cost of $2,218 in the first year. This value does not account for additional energy for electric water heater standby losses. The appropriately scaled first costs and operating cost estimates are shown in Table IV.31. In all but the no-new-standards replacement case, the residential-duty water heater is more expensive to install than the electric storage water heater; however, it was less costly to operate in all cases. For the cases in which the electric storage water heater was less expensive to install, the up-front cost premium of the gas-fired residential-duty unit relative to the electric storage unit, divided by the annual operating savings from using the gas water heater, yields a PBP of 0.16 years in the no-new-standards new installation case, of 0.22 years at the proposed standard level (TSL 3) replacement case, and of 0.57 years at the proposed standard level new installation case. Based on the comparison of costs for equivalent electric water heating, DOE has tentatively concluded that amended standards would not introduce additional economic incentives for fuel switching from residential-duty to electric storage water heaters.

TABLE IV.31—TYPICAL UNIT COSTS, SCALED FOR FIRST-HOUR RATING (RESIDENTIAL-DUTY = 1.0)—ELECTRIC STORAGE VERSUS RESIDENTIAL-DUTY

[2020$]

Equipment	Cost	No-new-standards case new construction	No-new-standards case replacement *	Standards case new construction	Standards case replacement *
Electric Storage	Installed Cost	$3,415	$3,208	$3,415	$3,208
	Energy, Maintenance, and Repair Cost (First Year).	2,257	2,257	2,257	2,257
Residential-duty Storage	Installed Cost	3,589	1,941	4,134	3,486

TABLE IV.31—TYPICAL UNIT COSTS, SCALED FOR FIRST-HOUR RATING (RESIDENTIAL-DUTY = 1.0)—ELECTRIC STORAGE VERSUS RESIDENTIAL-DUTY—Continued

[2020$]

Equipment	Cost	No-new-standards case new construction	No-new-standards case replacement *	Standards case new construction	Standards case replacement *
	Energy, Maintenance, and Repair Cost (First Year).	1,182	1,164	999	984

* Installed costs for electric storage water heaters shown for the replacement case do not include cost of infrastructure alterations (*e.g.,* upgraded wiring, removal or modification of gas infrastructure).

DOE did not consider instantaneous gas-fired equipment and electric storage water heaters to be likely objects of gas-to-electric fuel switching, largely due to the disparity in hot water delivery capacity between the instantaneous gas-fired equipment and commercial electric storage equipment. However, DOE understands that systems can be built by plumbing multiple individual water heaters together to achieve the same level of hot water delivery capacity. DOE seeks comment as to the extent that this phenomenon exists in either the no-standards case or the standards case. While technically feasible for consumers not facing space constraints, DOE considered it unlikely that these consumers would choose upon replacement to swap one or more high-output, typically wall-mounted tankless units with physically larger, floor-mounted electric storage water heaters for economic reasons, given the relatively low incremental operating cost for installing condensing tankless units and the much higher operational cost of the electric units. Commercial tankless water heaters could in theory be replaced with one or more electric tankless units. DOE also has tentatively concluded that this would be an unlikely scenario for the same reasons cited for switching to electric storage, however DOE also notes that without hot water storage in such a system the instantaneous electric heating load could disproportionally impact a commercial buildings electric demand in many applications relative to the equivalent electric storage water heater, requiring greater electrical infrastructure upgrades as well as potentially higher and less predictable ongoing electric demand costs. DOE has tentatively concluded that amended standards would not introduce additional economic incentives for fuel switching from gas-fired instantaneous tankless to electric storage or electric tankless water heaters. Similarly, replacement of gas fired circulating water heaters or boilers with an electric equivalent would be expected to require substantial electric capacity upgrades expected as well as much higher operating cost of the electric equipment. The representative 399 kBtu/h baseline gas-fired hot water boiler represents an approximately 94 kW electric instantaneous equivalent, anticipated to be a significant load increase to most commercial buildings that might otherwise use the gas-fired hot water boiler.

In summary, based upon the reasoning mentioned previously, DOE did not explicitly include fuel or technology switching in this NOPR beyond the continuation of historical trends discussed in section IV.G of this document.

Issue 8: DOE seeks comment on the availability of systems that can be built by plumbing multiple individual water heaters together to achieve the same level of hot water delivery capacity.

3. National Energy Savings

The NES analysis involves a comparison of national energy consumption of the considered equipment between each potential standards case (''TSL'') and the case with no new or amended energy conservation standards. DOE calculated the national energy consumption by multiplying the number of units (stock) of each product (by vintage or age) by the unit energy consumption (also by vintage). DOE calculated annual NES based on the difference in national energy consumption for the no-new-standards case and for each higher efficiency standard case. DOE estimated energy consumption and savings based on site energy and converted the electricity consumption and savings to primary energy (*i.e.,* the energy consumed by power plants to generate site electricity) using annual conversion factors derived from *AEO2021.* Cumulative energy savings are the sum of the NES for each year over the timeframe of the analysis.

In 2011, in response to the recommendations of a committee on ''Point-of-Use and Full-Fuel-Cycle Measurement Approaches to Energy Efficiency Standards'' appointed by the National Academy of Sciences, DOE announced its intention to use FFC measures of energy use and greenhouse gas and other emissions in the national impact analyses and emissions analyses included in future energy conservation standards rulemakings. 76 FR 51281 (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 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, multi-sector, partial equilibrium model of the U.S. energy sector [148] that EIA uses to prepare its *AEO.* The FFC factors incorporate losses in production and delivery in the case of natural gas (including fugitive emissions) and additional energy used to produce and deliver the various fuels used by power plants. The approach used for deriving FFC measures of energy use and emissions is described in appendix 10D of the NOPR TSD.

DOE calculated the NES associated with the difference between the per-unit energy use under a standards-case scenario and the per-unit energy use in the no-new-standards case. The average energy per unit used by the CWH equipment stock gradually decreases in the standards case relative to the no-new-standards case as more-efficient CWH units gradually replaces less-efficient units.

Unit energy consumption values for each equipment category are taken from the LCC spreadsheet for each efficiency level and weighted based on market efficiency distributions. To estimate the total energy savings for each efficiency level, DOE first calculated the per-unit energy reduction (*i.e.,* the difference between the energy directly consumed

[148] For more information on NEMS, refer to The National Energy Modeling System: An Overview 2018, DOE/EIA–0581(2018). April 2019. Available at *www.eia.gov/outlooks/aeo/nems/overview/pdf/0581(2018).pdf* (last accessed July 7, 2021).

by a unit of equipment in operation in the no-new-standards case and the standards case) for each class of CWH equipment for each year of the analysis period. The electricity and natural gas savings or increases (in the case of electricity used for condensing natural gas-fired water heaters) are accounted separately. Second, DOE determined the annual site energy savings by multiplying the stock of each equipment category by vintage (*i.e.,* year of shipment) by the per-unit energy reduction for each vintage (from step one). This second step adds to the electricity impacts an amount of energy savings/increase to account for the losses and inefficiencies in the generation, transmission, and distribution systems. The result of the second step yields primary electricity impacts at the generation source. The second step applies only to electricity; there is no analogous adjustment made to natural gas savings. Third, DOE converted the annual site electricity savings into the annual amount of energy saved at the source of electricity generation (the source or primary energy), using a time series of conversion factors derived from the latest version of EIA's NEMS. This third step accounts for the energy used to extract and transport fuel from mines or wells to the electric generation facilities, and accounts for the natural gas NES for drilling and pipeline energy usage. The third step yields the total FFC impacts. DOE accounts for the natural gas savings separately from the electricity impacts, so the factors used at each step are appropriate for the specific fuel. The coefficients developed for the analysis are mutually exclusive, so there should be no double-counting of impacts. Finally, DOE summed the annual primary energy savings for the lifetime of units shipped over a 30-year period to calculate the total NES. DOE performed these calculations for each efficiency level considered for CWH equipment in this rulemaking. DOE notes that for the LCC and PBP analyses, only site energy impacts are used. The only steps in the analysis wherein FFC savings are used are the calculation of NES. DOE notes that the development of data for site-to-source and other factors is accomplished by running the EIA's model used to generate the *AEO.* DOE has included with this NOPR TSD the previously mentioned chapter 10 and appendix 10D, which reference the development of the FFC factors and provide some of the underlying data.

Regarding the fossil fuel site-to-source values used in the NOPR analysis, DOE used the *AEO2021* Reference case, which reflects the most up-to-date information on resource and fuel costs, but excludes Clean Power Plan (CPP) [149] impacts. Use of the *AEO2021* also incorporates all Federal legislation and regulations in place when EIA prepared the analyses. The growing penetration of renewable electricity generation would have little effect on the trend in site-to-source energy factors because EIA uses an average fossil fuel heat to characterize the primary energy associated with renewable generation. At this time, DOE is continuing to use the ''fossil fuel equivalency'' accounting convention used by EIA. DOE notes the *AEO* projections stop in 2050. Because the trends were relatively flat, DOE maintained the 2050 value for the remainder of the forecast period. When DOE develops the site-to-source and FFC-factors, it models resource mixes representative of the load profile of the equipment covered in the rulemaking that vary by end-use. For this NOPR, DOE has used an average of resources compatible with the general load profile of CWH equipment, and the data used are the most current available.

DOE also considered whether a rebound effect is applicable in its NES analysis for CWH equipment. A rebound effect occurs when an increase in equipment efficiency leads to increased demand for its service. For example, when a consumer realizes that a more-efficient water heating device will lower the energy bill, that person may opt to increase his or her amenity level by taking longer showers and thereby consuming more hot water. In this way, the consumer gives up a portion of the energy cost savings in favor of the increased amenity. For the CWH equipment market, there are two ways that a rebound effect could occur: (1) Increased use of hot water within the buildings in which such units are installed and (2) additional hot water outlets that were not previously installed. Because the CWH equipment addressed in this proposed rule is commercial equipment, the person owning the equipment (*i.e.,* the apartment or commercial building owner) is usually not the person operating the equipment (*e.g.,* the apartment renter, or the restaurant employee using hot water to wash dishes). Because the operator usually does not own the equipment, that person will not have the operating cost information necessary to influence his or her operation of the equipment. Therefore, the first type of rebound is unlikely to occur at levels that could be considered significant. Similarly, the second type of rebound is unlikely because a small change in efficiency is insignificant among the factors that determine whether a company will invest the money required to pipe hot water to additional outlets.

In the October 2014 RFI, DOE sought comments and data on any rebound effect that may be associated with more-efficient commercial water heaters. 79 FR 62908 (Oct. 21, 2014). DOE received two comments. Both A.O. Smith and Joint Advocates did not believe a rebound effect would be significant. A.O. Smith commented that water usage is based on demand and more efficient water heaters would not change the demand. (A.O. Smith, No. 2 at p. 4) Joint Advocates commented that with the marginal change in energy bill for small business owners, they would expect little increased hot water usage, and that for tenant-occupied buildings, it would be ''difficult to infer that more tenants will wash their hands longer because the hot water costs the building owner less.'' Thus, Joint Advocates thought the likelihood of a strong rebound effect is very low. (Joint Advocates, No. 7 at p. 5) As DOE did not receive any comments suggesting the contrary in response to the withdrawn NOPR, DOE has retained its position that rebound effect is unlikely to occur for the CWH that are the subject of this NOPR.

4. Net Present Value Analysis

The inputs for determining the NPV of the total costs and benefits experienced by consumers are (1) total annual installed cost, (2) total annual operating costs (energy costs and repair and maintenance costs), and (3) a discount factor to calculate the present value of costs and savings. DOE calculates net savings each year as the difference between the no-new-standards case and each standards case in terms of total savings in operating costs versus total increases in installed costs. DOE calculates operating cost savings over the lifetime of each product shipped during the projection period. DOE determined the difference between the equipment costs under the standard case and the no-new-standards case in order to obtain the net equipment cost increase resulting from the higher standard level. As noted in section IV.F.2.a of this document, DOE used a constant real price assumption as the default price projection; the cost to manufacture a given unit of higher efficiency neither increases nor

[149] The CPP was repealed in June 2019 as part of EPA's final Affordable Clean Energy (''ACE'') Rule, but the ACE Rule was vacated in January 2021 by the United States Court of Appeals for the District of Columbia Circuit, who also remanded EPA to consider a new regulatory framework to replace the ACE Rule.

decreases over time. The analysis of the price trends is described in chapter 10 of the NOPR TSD.

The operating cost savings are energy cost savings, which are calculated using the estimated energy savings in each year and the projected price of the appropriate form of energy. To estimate energy prices in future years, DOE multiplied the average regional energy prices by the projection of annual national-average commercial energy price changes in the Reference case from *AEO2021,* which has an end year of 2050. To estimate price trends after 2050, DOE used the average annual rate of change in prices from 2020 through 2050. As part of the NIA, DOE also analyzed scenarios that used inputs from variants of the *AEO2021* Reference case that have lower and higher economic growth. Those cases have lower and higher energy price trends compared to the Reference case. NIA results based on these cases are presented in appendix 10B of the NOPR TSD.

DOE then determined the difference between the net operating cost savings and the net equipment cost increase in order to obtain the net savings (or expense) for each year. DOE then discounted the annual net savings (or expenses) to 2021 for CWH equipment bought on or after 2026 and summed the discounted values to provide the NPV for an efficiency level.

In calculating the NPV, DOE multiplies the net savings in future years by a discount factor to determine their present value. For this 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 OMB to Federal agencies on the development of regulatory analysis.[150] 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.

DOE considered the possibility that consumers make purchase decisions based on first cost instead of LCC. DOE projects that new installations meeting a potential standard would not cause the commercial gas-fired storage water heaters to be significantly more expensive than electric storage water heaters of comparable first-hour capacity, as detailed in section IV.H.2. of this document. DOE further notes that only the relative costs of purchasing, installing, and operating equipment were considered in its analysis, and did not consider unrelated issues such as current trends toward electrification of customer loads, as DOE cannot speculate about consumer electrification or other (*see* sections IV.G and IV.H.2 of this document).

DOE notes that governmental and corporate purchasing policies are increasingly resulting in purchases of more-efficient equipment. However, DOE does not infer anything with respect to the remaining market for efficient water heaters simply because of a purchase by one consumer or even by one segment of the consumer base, such as purchases by government consumers. In other words, if all Federal government agencies purchase ENERGY STAR-compliant water heaters, that tells us nothing about the installation costs experienced by any other consumers. DOE assumes the purchases reveal more about the underlying consumer discount rate premiums than about a distribution of installation costs. It is possible that corporate commitment to green purchasing policies might result in situations where, in their rational decision-making process, the consumer gives green purchase alternatives an explicit advantage. As an example, a purchasing policy may specify that that a ''non-green'' alternative must have a PBP of 3 years or less while a ''green'' alternative can have a PBP up to 5 years. This type of corporate decision making would have the outward appearance of providing an apparent discount rate advantage to the ''green'' alternative, or perhaps, an appearance of assessing a lower discount rate premium on the ''green'' alternative than is assessed on all other alternatives. Thus, while significant numbers of purchases are taking place in the market, DOE contends that such purchases reveal an underlying distribution of discount rate premiums rather than an underlying distribution of installation costs. Green policies and programs such as FEMP-designated equipment and ENERGY STAR will continue to effectively reduce even more consumers' discount rate premiums, leading to more green purchases. This assumption underlies DOE's decision to take the efficiency trends data provided by manufacturers and extend the trends into the future rather than holding efficiency constant at current rates.

To the extent that there may be concerns regarding the inconvenience and disruptions caused by installing new venting, DOE would note that installing commercial electric water heaters is not simply a matter of hauling the water heater into the building and plugging it into an existing power outlet. The typical unit DOE analyzed for this NOPR included 18 kilowatt (''kW'') heating elements, and in a setting where the electrical system cannot support a new load of this magnitude (or higher) without being upgraded, installation of an electric water heater might be no less disruptive and just as costly as the venting upgrade for a condensing gas-fired water heater. Within this NOPR analysis, DOE has considered the range of possible repairs and determined that there likely were few if any life-extending repairs that could be made beyond those included by DOE in the LCC and NIA analyses. For some equipment failures, such as tanks leaking, DOE knows of no good way to repair the equipment to extend the equipment's life, so life-extending repair is likely extremely limited beyond the repairs already included by DOE.

I. Consumer Subgroup Analysis

In analyzing the potential impact of new or amended standards on commercial consumers, DOE evaluates the impact on identifiable groups (*i.e.,* subgroups) of consumers, such as residential consumers at comparatively lower income levels that may be disproportionately affected by a new or revised national energy conservation standard level. The purpose of the subgroup analysis is to determine the extent of any such disproportionate impacts. For this rulemaking, DOE identified consumers at the lowest income bracket in the residential sector and only included them for a residential sector subgroup analysis. The following provides further detail regarding DOE's consumer subgroup analysis. Chapter 11 in the NOPR TSD describes the consumer subgroup analysis.

1. Residential Sector Subgroup Analysis

The RECS database divides the residential samples into 24 income bins. The income bins represent total gross annual household income. As far as discount rates are concerned, the survey of consumer finances divides the residential population into six different income bins: Income bin 1 (0–20 percent income percentile), income bin 2 (20–40 percent income percentile),

[150] United States Office of Management and Budget. Circular A–4: Regulatory Analysis. September 17, 2003. Section E. Available at *www.whitehouse.gov/sites/whitehouse.gov/files/omb/circulars/A4/a-4.pdf* (last accessed July 7, 2021).

income bin 3 (40–60 percent income percentile), income bin 4 (60–80 percent income percentile), income bin 5 (80–90 percent income percentile), and income bin 6 (90–100 percent income percentile). In general, consumers in the lower income groups tend to discount future streams of benefits at a higher rate when compared to consumers in the higher income groups.

Hence, to analyze the influence of a national standard on the low-income group population, DOE conducted a (residential) subgroup analysis where only the 0–20 percent income percentile samples were included for the entire simulation run. Subsequently, the results of the subgroup analysis are compared to the results from all consumers.

The results of DOE's LCC subgroup analysis are summarized in section V.B.1.b of this NOPR and described in detail in chapter 11 of the NOPR TSD.

J. Manufacturer Impact Analysis

1. Overview

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

The quantitative part of the MIA primarily relies on GRIM, an industry cash flow model with inputs specific to this rulemaking. The key GRIM inputs include data on the industry cost structure, unit production costs, product shipments, manufacturer markups, and investments in R&D and manufacturing capital required to produce compliant products. The key GRIM outputs are the INPV, which is the sum of industry annual cash flows over the analysis period, discounted using the industry-weighted average cost of capital, and the impact to domestic manufacturing employment. The model uses standard accounting principles to estimate the impacts of more-stringent energy conservation standards on a given industry by comparing changes in INPV and domestic manufacturing employment between a no-new-standards case and the various standards cases (*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 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 proposed rulemaking in three phases. In Phase 1 of the MIA, DOE prepared a profile of the CWH equipment manufacturing industry based on the market and technology assessment, preliminary manufacturer interviews, and publicly-available information. This included a top-down analysis of CWH equipment manufacturers that DOE used to derive preliminary financial inputs for the GRIM (*e.g.,* revenues; materials, labor, overhead, and depreciation expenses; selling, general, and administrative (''SG&A'') expenses; and R&D expenses). DOE also used public sources of information to further calibrate its initial characterization of the CWH equipment manufacturing industry, including company filings of form 10–K from the SEC,[151] corporate annual reports, the U.S. Census Bureau's Economic Census,[152] and reports from Dunn & Bradstreet.[153]

In Phase 2 of the MIA, DOE prepared a framework industry cash-flow analysis to quantify the potential impacts of amended energy conservation standards. The GRIM uses several factors to determine a series of annual cash flows starting with the announcement of the standard and extending over a 30-year period following the compliance date of the standard. These factors include annual expected revenues, costs of sales, SG&A and R&D expenses, taxes, and capital expenditures. In general, energy conservation standards can affect manufacturer cash flow in three distinct ways: (1) Creating a need for increased investment, (2) raising production costs per unit, and (3) altering revenue due to higher per-unit prices and changes in sales volumes.

In addition, during Phase 2, DOE developed interview guides to distribute to manufacturers of CWH equipment in order to develop other key GRIM inputs, including product and capital conversion costs, and to gather additional information on the anticipated effects of energy conservation standards on revenues, direct employment, capital assets, industry competitiveness, and subgroup impacts.

In Phase 3 of the MIA, DOE conducted structured, detailed interviews with representative manufacturers. During these interviews, DOE discussed engineering, manufacturing, procurement, and financial topics to validate assumptions used in the GRIM and to identify key issues or concerns. As part of Phase 3, DOE also evaluated subgroups of manufacturers that may be disproportionately impacted by amended standards or that may not be accurately represented by the average cost assumptions used to develop the industry cash flow analysis. Such manufacturer subgroups may include small business manufacturers, low-volume manufacturers, niche players, and/or manufacturers exhibiting a cost structure that largely differs from the industry average. DOE identified one subgroup for a separate impact analysis: Small business manufacturers. The small business subgroup is discussed in section VI.B ''Review under the Regulatory Flexibility Act'' 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 an amended energy conservation standard. The GRIM spreadsheet uses the inputs to arrive at a series of annual cash flows, beginning in 2020 (the base year of the analysis)

[151] U.S. Securities and Exchange Commission, Annual 10–K Reports (Various Years) (Available at *www.sec.gov/edgar/searchedgar/companysearch.html*).

[152] U.S. Census Bureau, Annual Survey of Manufacturers: General Statistics: Statistics for Industry Groups and Industries (2018). Available at *www.census.gov/data/tables/time-series/econ/asm/2018-2019-asm.html.*

[153] Dunn & Bradstreet Company Profiles, Various Companies. Available at *app.dnbhoovers.com.*

and continuing to 2055. DOE calculated INPVs by summing the stream of annual discounted cash flows during this period. For manufacturers of CWH equipment, DOE used a real discount rate of 9.1 percent, which was derived from industry financials and then modified according to feedback received during manufacturer interviews.

The GRIM calculates cash flows using standard accounting principles and compares changes in INPV between the no-new-standards case and each standards case. The difference in INPV between the no-new-standards case and a standards case represents the financial impact of the amended energy conservation standard on manufacturers. As discussed previously, DOE developed critical GRIM inputs using a number of sources, including publicly-available data, results of the engineering analysis, and information gathered from industry stakeholders during the course of manufacturer interviews and through written comments. The GRIM results are presented in section V.B.2. Additional details about the GRIM, the discount rate, and other financial parameters can be found in chapter 12 of the NOPR TSD.

a. Manufacturer Production Costs

Manufacturing more efficient equipment is typically more expensive than manufacturing baseline equipment due to the use of more complex components, which are typically more costly than baseline components. The changes in the MPCs of covered products can affect the revenues, gross margins, and cash flow of the industry. MPCs were derived in the engineering analysis, using methods discussed in section IV.C. of this document. For a complete description of the MPCs, see chapter 5 of the NOPR TSD.

b. Shipments Projections

The GRIM estimates manufacturer revenues based on total unit shipment projections and the distribution of those shipments by efficiency level. Changes in sales volumes and efficiency mix over time can significantly affect manufacturer finances. For this analysis, the GRIM uses the NIA's annual shipment projections derived from the shipments analysis from 2020 (the base year) to 2055 (the end year of the analysis period). See chapter 9 of the NOPR TSD for additional details.

c. Product and Capital Conversion Costs

Amended energy conservation standards could cause manufacturers to incur conversion costs to bring their production facilities and equipment designs into compliance. DOE evaluated the level of conversion-related expenditures that would be needed to comply with each considered efficiency level in each equipment category. For the MIA, DOE classified these conversion costs into two major groups: (1) Product conversion costs; and (2) capital conversion costs.

Product conversion costs are investments in research, development, testing, marketing, and other non-capitalized costs necessary to make product designs comply with amended energy conservation standards. Capital conversion costs are investments in property, plant, and equipment necessary to adapt or change existing production facilities such that new compliant product designs can be fabricated and assembled.

To evaluate potential product conversion costs, DOE estimated the number of platforms manufacturers would have to modify to move their equipment lines to each incremental efficiency level. DOE developed the product conversion costs by estimating the amount of labor per platform manufacturers would need for research and development to raise the efficiency of models to each incremental efficiency level. DOE also assumed manufacturers would incur safety certification costs (including costs for updating safety certification records and for safety testing) associated with modifying their current product offerings to comply with amended standards.

To evaluate the level of capital conversion expenditures manufacturers would likely incur to comply with amended standards, DOE used information derived from the engineering analysis, equipment teardowns, and manufacturer interviews. DOE used the information to estimate the additional investments in property, plant, and equipment that are necessary to meet amended energy conservation standards. In the engineering analysis evaluation of higher efficiency equipment from leading manufacturers of commercial water heaters (both commercial duty and residential duty), DOE found a range of designs and manufacturing approaches. DOE attempted to account for both the range of manufacturing pathways and the current efficiency distribution of shipments in the modeling of industry capital conversion costs.

The capital conversion cost estimates for gas-fired storage water heaters are driven by the cost for industry to double production capacity at condensing ELs. Those costs included, but were not limited to, capital investments in tube bending, press dies, machining, enameling, MIG welding, leak testing, quality assurance stations, conveyer, and additional space requirements.

For gas-fired instantaneous water heaters capital conversion costs, DOE understands that manufacturers produce commercial models on the same production lines as residential models, which have much higher shipment volumes. As such, DOE modeled the scenario in which gas-fired instantaneous water heater manufacturers make incremental investments to increase production capacity, but do not need to setup entirely new production lines or new facilities to accommodate an amended standard requiring condensing technology for gas-fired instantaneous water heaters.

For gas-fired instantaneous circulating water heaters and hot water supply boilers, the design changes to reach condensing efficiency levels were driven by purchased parts (*i.e.,* condensing heat exchanger, burner tube, blower, gas valve). The capital conversion costs for this equipment class are based on incremental warehouse space needed to house additional purchased parts.

DOE assumes all conversion-related investments occur between the year of publication of the final rule and the year by which manufacturers must comply with the new standard. The conversion cost figures used in the GRIM can be found in section V.B.2 of this document. For additional information on the estimated capital and product conversion costs and estimates by equipment category, see chapter 12 of the NOPR TSD.

Issue 9: DOE seeks input on the production facility and manufacturing process changes required as a result of potential amended standards for each equipment category. DOE also requests input on the costs associated with those facility and manufacturing changes.

d. Manufacturer Markup Scenarios

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

Under the preservation of gross margin percentage scenario, DOE applied a single uniform ''gross margin percentage'' markup across all efficiency levels, which assumes that manufacturers would be able to maintain the same amount of profit as a percentage of revenues at all efficiency levels within an equipment category. As manufacturer production costs increase with efficiency, this scenario implies that the absolute dollar markup will increase.

To estimate the average manufacturer markup used in the preservation of gross margin percentage markup scenario, DOE analyzed publicly-available financial information for manufacturers of CWH equipment. DOE then requested feedback on its initial markup estimates during manufacturer interviews. The revised markups, which are used in DOE's quantitative analysis of industry financial impacts, are presented in Table IV.32 of this NOPR. These markups capture all non-production costs, including SG&A expenses, R&D expenses, interest expenses, and profit.

TABLE IV.32—MANUFACTURER MARKUPS FOR PRESERVATION OF GROSS MARGIN PERCENTAGE MARKUP SCENARIO

Equipment	Markup
Commercial gas-fired storage and gas-fired storage-type instantaneous water heaters	1.45
Residential-duty gas-fired storage water heaters	1.45
Gas-fired instantaneous water heaters and hot water supply boilers:	
Tankless water heaters	1.43
Circulating water heaters and hot water supply boilers	1.43

DOE also models the preservation of per-unit operating profit scenario because manufacturers stated that they do not expect to be able to mark up the full cost of production in the standards case, given the highly competitive nature of the CWH market. In this scenario, manufacturer markups are set so that operating profit one year after the compliance date of amended energy conservation standards is the same as in the no-new-standards case on a per-unit basis. In other words, manufacturers are not able to garner additional operating profit from the higher production costs and the investments that are required to comply with the amended standards; however, they are able to maintain the same per-unit operating profit in the standards case that was earned in the no-new-standards case. Therefore, operating margin in percentage terms is reduced between the no-new-standards case and standards case.

DOE adjusted the manufacturer markups in the GRIM at each TSL to yield approximately the same per-unit earnings before interest and taxes in the standards case as in the no-new-standards case. The preservation of per-unit operating profit markup scenario represents the lower bound of industry profitability in the standards case. This is because manufacturers are not able to fully pass through to commercial consumers the additional costs necessitated by amended standards for CWH equipment.

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

K. Emissions Analysis

The emissions analysis consists of two components. The first component estimates the effect of potential energy conservation standards on power sector and site (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 power sector emissions of CO_2, NO_X, SO_2, and Hg uses marginal emissions factors that were derived from data in *AEO2021,* as described in section IV.M of this document. Details of the methodology are described in the appendices to chapters 13 and 15 of the NOPR TSD.

Power sector emissions of CO_2, CH_4, and N_2O are estimated using Emission Factors for Greenhouse Gas Inventories published by the EPA.[154] The FFC upstream emissions are estimated based on the methodology described in chapter 15 of the NOPR TSD. The upstream emissions include both emissions from extraction, processing, and transportation of fuel, and ''fugitive'' emissions (direct leakage to the atmosphere) of CH_4 and CO_2.

The onsite operation of CWH equipment requires combustion of fossil fuels and results in emissions of CO_2, NO_X, SO_2, CH_4 and N_2O at the sites where these products are used. DOE accounted for the reduction in these site emissions and the associated FFC upstream emissions due to potential standards. Site emissions of these gases were estimated using Emission Factors for Greenhouse Gas Inventories and emissions intensity factors from an EPA publication.[155]

The emissions intensity factors are expressed in terms of physical units per megawatt-hour (MWh) or million British thermal units (MMBtu) of site energy savings. 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 *AEO2021,* which incorporates the projected impacts of existing air quality regulations on emissions. *AEO2021* generally represents current legislation and environmental regulations, including recent government actions, that were in place at the time of preparation of *AEO2021,* including the emissions control programs discussed in the following paragraphs.[156]

[154] Available *www.epa.gov/sites/production/files/2021-04/documents/emission-factors_apr2021.pdf* (last accessed July 12, 2021).

[155] U.S. Environmental Protection Agency. External Combustion Sources. In Compilation of Air Pollutant Emission Factors. AP–42. Fifth Edition. Volume I: Stationary Point and Area Sources. Chapter 1. Available at *www.epa.gov/air-emissions-factors-and-quantification/ap-42-compilation-air-emissions-factors* (last accessed July 1, 2021).

[156] For further information, see the Assumptions to *AEO2021* report that sets forth the major

Continued

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 (''CAA'') sets an annual emissions cap on SO_2 for affected EGUs in the 48 contiguous States and the District of Columbia (''D.C.''). (42 U.S.C. 7651 *et seq.*) SO_2 emissions from numerous States in the eastern half of the United States are also limited under the Cross-State Air Pollution Rule (''CSAPR''). 76 FR 48208 (Aug. 8, 2011). CSAPR requires these States to reduce certain emissions, including annual SO_2 emissions, and went into effect as of January 1, 2015.[157] *AEO2021* incorporates implementation of CSAPR, including the update to the CSAPR ozone season program emission budgets and target dates issued in 2016. 81 FR 74504 (Oct. 26, 2016). Compliance with CSAPR is flexible among EGUs and is enforced through the use of tradable emissions allowances. Under existing EPA regulations, 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. 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 *AEO2021*.

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, NO_X 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 NO_X 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 *AEO2021* data to derive NO_X emissions factors for the group of States not covered by CSAPR. DOE used *AEO2021* 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 *AEO2021,* which incorporates the MATS.

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.

On March 16, 2022, the Fifth Circuit Court of Appeals (No. 22–30087) granted the federal government's emergency motion for stay pending appeal of the February 11, 2022, preliminary injunction issued in *Louisiana* v. *Biden,* No. 21–cv–1074–JDC–KK (W.D. La.). As a result of the Fifth Circuit's order, the preliminary injunction is no longer in effect, pending resolution of the federal government's appeal of that injunction or a further court order. Among other things, the preliminary injunction enjoined the defendants in that case from ''adopting, employing, treating as binding, or relying upon'' the interim estimates of the social cost of greenhouse gases—which were issued by the Interagency Working Group on the Social Cost of Greenhouse Gases on February 26, 2021—to monetize the benefits of reducing greenhouse gas emissions. In the absence of further intervening court orders, DOE will revert to its approach prior to the injunction and present monetized benefits where appropriate and permissible under law. DOE requests comment on how to address the climate benefits and other non-monetized effects of the proposal.

1. Monetization of Greenhouse Gas Emissions

For the purpose of complying with the requirements of Executive Order 12866, DOE estimates the monetized benefits of the reductions in emissions of CO_2, CH_4, and N_2O by using a measure of the social cost (''SC'') of each pollutant (*e.g.,* SC–GHGs). 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

assumptions used to generate the projections in the Annual Energy Outlook. Available at *www.eia.gov/outlooks/aeo/assumptions/* (last accessed July 1, 2021).

[157] CSAPR requires states to address annual emissions of SO_2 and NO_X, precursors to the formation of fine particulate matter ($PM_{2.5}$) pollution, in order to address the interstate transport of pollution with respect to the 1997 and 2006 $PM_{2.5}$ National Ambient Air Quality Standards (''NAAQS''). CSAPR also requires certain states to address the ozone season (May–September) emissions of NO_X, a precursor to the formation of ozone pollution, in order to address the interstate transport of ozone pollution with respect to the 1997 ozone NAAQS. 76 FR 48208 (Aug. 8, 2011). EPA subsequently issued a supplemental rule that included an additional five states in the CSAPR ozone season program; 76 FR 80760 (Dec. 27, 2011) (Supplemental Rule).

presenting monetized climate benefits as recommended by applicable Executive Orders and guidance, and DOE would reach the same conclusion presented in this notice in the absence of the social cost of greenhouse gases, including the February 2021 Interim Estimates presented by the Interagency Working Group on the Social Cost of Greenhouse Gases.

DOE estimated the global social benefits of CO_2, CH_4, and N_2O reductions (''SC–GHG'') using the estimates presented in the ''Technical Support Document: Social Cost of Carbon, Methane, and Nitrous Oxide Interim Estimates under Executive Order 13990'' published in February 2021 by the Interagency Working Group on Social Cost of Greenhouse Gases, United States Government (IWG) (IWG, 2021). 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, the 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, an interagency working group (IWG) that included 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 (ECS)—a measure of the globally averaged temperature response to increased atmospheric CO_2 concentrations. These estimates were updated in 2013 based on new versions of each IAM. In August 2016 the IWG published estimates of the 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. (2015) 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 to various components of the estimation process (National Academies, 2017). 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'' (E.O. 13783, Section 5(c)).

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, specifically the SC–CH_4 estimates, are used here to estimate the climate benefits for this proposed rule. The E.O. instructs the IWG to undertake a fuller update of the SC–GHG estimates by January 2022 that takes into consideration the advice of the National Academies (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 a global perspective is essential for SC–GHG estimates because it fully captures climate impacts that affect the United States and which have been omitted from prior U.S.-specific estimates due to methodological constraints. Examples of omitted effects include direct effects on U.S. citizens, assets, and investments located abroad, supply chains, and tourism, and spillover pathways such as economic and political destabilization and global migration. 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. 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. 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. Prior to that, in 2008 DOE presented Social Cost of Carbon (SCC) estimates based on values the Intergovernmental Panel on Climate Change (IPCC) identified in literature at that time. 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 (IWG 2010, 2013, 2016a, 2016b), and recommended that discount rate uncertainty and relevant aspects of intergenerational ethical considerations be accounted for in selecting future discount rates. 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 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.

DOE's derivations of the SC–GHGs (*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 pollutants are presented in section V.B.6.

a. Social Cost of Carbon

The SC–CO_2 values used for this NOPR were generated using the values presented in the 2021 update from the IWG's February 2021 TSD. Table IV.33 shows the updated sets of SC–CO_2 estimates from the latest interagency update in 5-year increments from 2020 to 2050. The full set of annual values used is presented in Appendix 14A of the NOPR TSD. For purposes of capturing the uncertainties involved in regulatory impact analysis, DOE has determined it is appropriate to include all four sets of SC–CO_2 values, as recommended by the IWG.[158]

TABLE IV.33—ANNUAL SC–CO_2 VALUES FROM 2021 INTERAGENCY UPDATE, 2020–2050

[2020$ per metric ton CO_2]

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

In calculating the potential global benefits resulting from reduced CO_2 emissions, DOE used the values from the 2021 interagency report, adjusted to 2020$ using the implicit price deflator for gross domestic product (''GDP'') from the Bureau of Economic Analysis. For each of the four sets of SC–CO_2 cases specified, the values for emissions in 2020 were $14, $51, $76, and $152 per metric ton avoided (values expressed in 2020$). DOE derived values from 2051 to 2070 based on estimates published by EPA.[159] These estimates are based on methods, assumptions, and parameters identical to the 2020–2050 estimates published by the IWG. DOE derived values after 2070 based on the trend in 2060–2070 in each of the four cases in the IWG update.

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. 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. See chapter 13 for the annual emissions

[158] 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.

[159] See EPA, *Revised 2023 and Later Model Year Light-Duty Vehicle GHG Emissions Standards: Regulatory Impact Analysis,* Washington, DC, December 2021. Available at: *https://www.epa.gov/system/files/documents/2021-12/420r21028.pdf* (last accessed January 13, 2022).

reduction. See appendix 14A of the TSD for the annual SC–CO_2 values.

b. Social Cost of Methane and Nitrous Oxide

The SC–CH_4 and SC–N_2O values used for this NOPR were generated using the values presented in the February 2021 update from the IWG.[160] Table IV.34 shows the updated sets of SC–CH_4 and SC–N_2O estimates from the latest interagency update in 5-year increments from 2020 to 2050. The full set of annual values used is presented in Appendix 14A of the 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.

TABLE IV.34—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	1,500	2,000	3,900	5,800	18,000	27,000	48,000
2025	800	1,700	2,200	4,500	6,800	21,000	30,000	54,000
2030	940	2,000	2,500	5,200	7,800	23,000	33,000	60,000
2035	1,100	2,200	2,800	6,000	9,000	25,000	36,000	67,000
2040	1,300	2,500	3,100	6,700	10,000	28,000	39,000	74,000
2045	1,500	2,800	3,500	7,500	12,000	30,000	42,000	81,000
2050	1,700	3,100	3,800	8,200	13,000	33,000	45,000	88,000

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. To calculate a present value of the stream of monetary values, DOE discounted the values in each of the cases using the specific discount rate that had been used to obtain the SC–CH_4 and SC–N_2O estimates in each case. See chapter 13 for the annual emissions reduction. See appendix 14A for the annual SC–CH_4 and SC_N_2O values.

2. Monetization of Other Air Pollutants

DOE estimated the monetized value of NO_X and SO_2 emissions reductions from electricity generation using benefit per ton estimates based on air quality modeling and concentration-response functions conducted by EPA for the Clean Power Plan final rule. 84 FR 32520. DOE used EPA's reported values for NO_X (as $PM_{2.5}$) and SO_2 for 2020, 2025, and 2030 calculated with discount rates of 3 percent and 7 percent, and EPA's values for ozone season NO_X, which do not involve discounting since the impacts are in the same year as emissions. DOE derived values specific to the sector for commercial water heating using a method described in appendix 14B of the NOPR TSD. DOE used linear interpolation to define values for the years between 2020 and 2025 and between 2025 and 2030; for years beyond 2030 the values are held constant.

DOE estimated the monetized value of NO_X and SO_2 emissions reductions from commercial water heating equipment using 2022 benefit-per-ton estimates from the EPA's ''Technical Support Document Estimating the Benefit per Ton of Reducing $PM_{2.5}$ and Ozone Precursors from 21 Sectors'' (''EPA TSD'').[161] Although none of the sectors refers specifically to residential and commercial buildings, and by association, commercial water heaters, the sector called ''area sources'' would be a reasonable proxy for residential and commercial buildings. ''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. The EPA TSD provides high and low estimates for 2016, 2020, 2025, and 2030 at 3- and 7-percent discount rates. DOE primarily relied on the low estimates to be conservative.

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. DOE will continue to evaluate the monetization of avoided NO_X and SO_2 emissions and will make any appropriate updates for the final rule.

M. Utility Impact Analysis

The utility impact analysis estimates several effects on the electric power generation industry that would result from the adoption of new or amended energy conservation standards. The utility impact analysis estimates the changes in installed electrical capacity and generation that would result for each TSL. The analysis is based on published output from the NEMS associated with *AEO2021.* 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 *AEO2021* 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.

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

[161] U.S. Environmental Protection Agency. Technical Support Document: Estimating the Benefit per Ton of Reducing $PM_{2.5}$ and Ozone Precursors from 21 Sectors, available at: *www.epa.gov/benmap/estimating-benefit-ton-reducing-directly-emitted-pm25-pm25-precursors-and-ozone-precursors.*

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, their suppliers, and related service firms. The MIA addresses those impacts. Indirect employment impacts are changes in national employment that occur due to the shift in expenditures and capital investment caused by the purchase and operation of more-efficient appliances. Indirect employment impacts from standards consist of the net jobs created or eliminated in the national economy, other than in the manufacturing sector being regulated, caused by (1) reduced spending by consumers on energy, (2) reduced spending on new energy supply by the utility industry, (3) increased consumer spending on the products to which the new standards apply and other goods and services, and (4) the effects of those three factors throughout the economy.

One method for assessing the possible effects on the demand for labor of such shifts in economic activity is to compare sector employment statistics developed by the Labor Department's Bureau of Labor Statistics (''BLS''). BLS regularly publishes its estimates of the number of jobs per million dollars of economic activity in different sectors of the economy, as well as the jobs created elsewhere in the economy by this same economic activity. Data from BLS indicate that expenditures in the utility sector generally create fewer jobs (both directly and indirectly) than expenditures in other sectors of the economy.[162] 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'').[163] ImSET is a special-purpose version of the ''U.S. Benchmark National Input-Output'' (''I–O'') model, which was designed to estimate the national employment and income effects of energy-saving technologies. The ImSET software includes a computer-based I–O model having structural coefficients that characterize economic flows among 187 sectors most relevant to industrial, commercial, and residential building energy use.

DOE notes that ImSET is not a general equilibrium forecasting model, and that the uncertainties involved in projecting employment impacts, especially changes in the later years of the analysis. Because ImSET does not incorporate price changes, the employment effects predicted by ImSET may over-estimate actual job impacts over the long run for this proposed rule. Therefore, DOE used ImSET only to generate results for near-term timeframes (2026–2030), where these uncertainties are reduced. For more details on the employment impact analysis, see chapter 16 of the 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 CWH equipment. It addresses the TSLs examined by DOE and the projected impacts of each of these levels. 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 amended standards for products and equipment by grouping individual efficiency levels for each class into TSLs. Use of TSLs allows DOE to identify and consider manufacturer cost interactions between the equipment classes, to the extent that there are such interactions, and market cross elasticity from consumer purchasing decisions that may change when different standard levels are set.

In the analysis conducted for this NOPR, for commercial gas-fired storage water heaters, DOE included efficiency levels for both thermal efficiency and standby loss in each TSL because standby loss is dependent upon thermal efficiency. This dependence of standby loss on thermal efficiency is discussed in detail in section IV.C.4.b of this NOPR and chapter 5 of the NOPR TSD. However, as discussed in section IV.C.4.b of this NOPR, for all thermal efficiency levels for commercial gas-fired storage water heaters, DOE only analyzed one standby loss level corresponding to each thermal efficiency level. The thermal efficiency levels for commercial gas-fired storage water heaters and commercial gas-fired instantaneous water heaters and hot water supply boilers, the standby loss levels for commercial gas-fired storage water heaters, and the UEF levels for residential-duty gas-fired storage water heaters that are included in each TSL are described in the following paragraphs and presented in Table V.1 of this NOPR.

TSL 4 consists of the max-tech efficiency levels for each equipment category, which correspond to the highest condensing efficiency levels. TSL 3 consists of intermediate condensing efficiency levels for commercial gas-fired storage water heaters and residential-duty gas-fired storage water heaters, and max-tech efficiency levels for commercial gas-fired instantaneous water heaters and hot water supply boilers. TSL 2 consists of the minimum condensing efficiency levels analyzed for commercial gas-fired storage water heaters and residential-duty gas-fired storage water heaters, and intermediate condensing efficiency levels for commercial gas-fired instantaneous water heaters and hot water supply boilers. These TSLs require similar technologies to achieve the efficiency levels and have roughly comparable equipment availability across each equipment category in terms of the share of models available that meet the efficiency level and having multiple manufacturers that produce those models. TSL 1 consists of the maximum non-condensing thermal efficiency or UEF (as applicable) levels analyzed for each equipment category.

Table V.1 presents the efficiency levels for each equipment category (*i.e.,* commercial gas-fired storage water heaters and storage-type instantaneous water heaters, residential-duty gas-fired storage water heaters, gas-fired tankless water heaters, and gas-fired circulating water heaters and hot water supply

[162] 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 *apps.bea.gov/scb/pdf/regional/perinc/meth/rims2.pdf* (last accessed July 7, 2021).

[163] 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.

boilers) in each TSL. Table V.2 presents the thermal efficiency value and standby loss reduction factor for each equipment category in each TSL that DOE considered, with the exception of residential-duty gas-fired storage water heaters (for which TSLs are shown separately in Table V.3). The standby loss reduction factor is a multiplier representing the reduction in allowed standby loss relative to the current standby loss standard and which corresponds to the associated increase in thermal efficiency. Table V.3 presents the UEF equations for residential-duty gas-fired storage water heaters corresponding to each TSL that DOE considered.

TABLE V.1—TRIAL STANDARD LEVELS FOR CWH EQUIPMENT BY EFFICIENCY LEVEL

Equipment	Trial standard level * **							
	1		2		3		4	
	E_t or UEF EL	SL EL	E_t or UEF EL	SL EL	E_t or UEF EL	SL EL	E_t or UEF EL	SL EL
Commercial gas-fired storage water heaters and storage-type instantaneous water heaters	1	0	2	0	4	0	5	0
Residential-duty gas-fired storage water heaters	2	....	3	....	4	....	5	....
Gas-fired instantaneous water heaters and hot water supply boilers:								
Tankless water heaters	2	....	4	....	5	....	5	....
Circulating water heaters and hot water supply boilers	2	....	4	....	5	....	5	....

* E_t stands for thermal efficiency, SL stands for standby loss, UEF stands for uniform energy factor, and EL stands for efficiency level. E_t applies to commercial gas-fired storage water heaters and storage-type instantaneous water heaters, and to gas-fired instantaneous water heaters and hot water supply boilers. SL applies to commercial gas-fired storage water heaters and storage-type instantaneous water heaters. UEF applies to residential-duty gas-fired storage water heaters.

** As discussed in sections III.B.6 and III.B.7 of this NOPR, DOE did not analyze amended standby loss standards for instantaneous water heaters and hot water supply boilers. In addition, standby loss standards are not applicable for residential-duty commercial gas-fired storage water heaters. Lastly, for commercial gas-fired storage water heaters and storage-type instantaneous water heaters DOE only analyzed the reduction that is inherent to increasing E_t and did not analyze SL ELs above EL0.

TABLE V.2—TRIAL STANDARD LEVELS FOR CWH EQUIPMENT BY THERMAL EFFICIENCY AND STANDBY LOSS REDUCTION FACTOR

[Except Residential-Duty Gas-Fired Storage Water Heaters]

Equipment	Trial standard level * **							
	1		2		3		4	
	E_t (percent)	SL factor †	E_t (percent)	SL factor †	E_t (percent)	SL factor †	E_t (percent)	SL factor †
Commercial gas-fired storage water heaters and storage-type instantaneous water heaters	82	0.98	90	0.91	95	0.86	99	0.83
Gas-fired instantaneous water heaters and hot water supply boilers:								
Tankless water heaters	84	....	94	....	96	....	96	....
Circulating water heaters and hot water supply boilers	84	....	94	....	96	....	96	....

* E_t stands for thermal efficiency, and SL stands for standby loss.

** As discussed in sections III.B.6 and III.B.7 of this NOPR, DOE did not analyze amended standby loss standards for instantaneous water heaters and hot water supply boilers.

† Standby loss reduction factor is a factor that is multiplied by the current maximum standby loss equations for each equipment class, as applicable. DOE used reduction factors to develop the amended maximum standby loss equation for each TSL. These reduction factors and maximum standby loss equations are discussed in section IV.C.5 of this NOPR.

TABLE—V.3 TRIAL STANDARD LEVELS BY UEF FOR RESIDENTIAL-DUTY GAS-FIRED STORAGE WATER HEATERS

Draw pattern *	Trial standard level **			
	1	2	3	4
	UEF	UEF	UEF	UEF
High	0.7497 − 0.0009*Vr	0.8397 − 0.0009*Vr	0.9297 − 0.0009*Vr	0.9997 − 0.0009*Vr
Medium	0.6902 − 0.0011*Vr	0.7802 − 0.0011*Vr	0.8702 − 0.0011*Vr	0.9402 − 0.0011*Vr
Low	0.6262 − 0.0012*Vr	0.7162 − 0.0012*Vr	0.8062 − 0.0012*Vr	0.8762 − 0.0012*Vr
Very Small	0.3574 − 0.0009*Vr	0.4474 − 0.0009*Vr	0.5374 − 0.0009*Vr	0.6074 − 0.0009*Vr

* Draw pattern is a classification of hot water use of a consumer water heater or residential-duty commercial water heater, based upon the first-hour rating. The draw pattern is determined using the Uniform Test Method for Measuring the Energy Consumption of Water Heaters in in appendix E to subpart B of 10 CFR part 430.

** Vr is rated volume in gallons.

DOE constructed the TSLs for this 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.[164]

B. Economic Justification and Energy Savings

1. Economic Impacts on Individual Consumers

DOE analyzed the economic impacts on CWH equipment consumers by looking at the effects that potential amended standards at each TSL would have on the LCC and PBP. DOE also examined the impacts of potential standards on selected consumer subgroups. These analyses are discussed in the following sections.

a. Life-Cycle Cost and Payback Period

In general, higher-efficiency products can affect consumers in two ways: (1) Purchase price increases and (2) annual operating costs decrease. Inputs used for calculating the LCC and PBP include total installed costs (*i.e.,* product price plus installation costs) and operating costs (*i.e.,* annual energy use, energy prices, energy price trends, repair costs, and maintenance costs). The LCC calculation also uses product lifetime and a discount rate. Chapter 8 of the NOPR TSD provides detailed information on the LCC and PBP analyses.

Table V.4 through Table V.13 of this NOPR show the LCC and PBP results for the TSLs considered in this NOPR. 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.2.i of this document). Because some consumers purchase products with higher efficiency in the no-new-standards case, the average savings are less than the difference between the average LCC of the baseline product and the average LCC at each TSL. The savings refer only to consumers who are affected by a standard at a given TSL. As was noted in IV.H.1, DOE assumes a large percentage of consumers are already purchasing higher efficiency condensing equipment by 2027. Those who already purchase a product with efficiency at or above a given TSL are not affected. Consumers for whom the LCC increases at a given TSL experience a net cost.

TABLE V.4—AVERAGE LCC AND PBP RESULTS FOR COMMERCIAL GAS-FIRED STORAGE WATER HEATERS AND STORAGE-TYPE INSTANTANEOUS WATER HEATERS

TSL *	Thermal efficiency (E_t) (percent)	Standby loss (SL) factor	Average costs (2020$)				Simple payback period (years)
			Installed cost	First year's operating cost	Lifetime operating cost	LCC	
0	80	1.00	5,145	1,888	17,874	23,018	
1	82	0.98	5,186	1,850	17,558	22,744	1.1
2	90	0.91	6,240	1,728	16,587	22,828	7.0
3	95	0.86	6,306	1,653	16,031	22,338	5.2
4	99	0.83	6,387	1,599	15,584	21,971	4.5

* The results for each TSL are calculated assuming that all consumers use equipment with that efficiency level. The PBP is measured relative to the baseline equipment.
Note: TSL 0 represents the baseline.

TABLE V.5—AVERAGE LCC SAVINGS RELATIVE TO THE NO-NEW-STANDARDS CASE FOR COMMERCIAL GAS-FIRED STORAGE WATER HEATERS AND STORAGE-TYPE INSTANTANEOUS WATER HEATERS

TSL	Thermal efficiency (E_t) level (percent)	Standby loss (SL) factor	Life-cycle cost savings		
			Percentage of commercial consumers that experience a net cost	Percentage of commercial consumers that experience a net benefit	Average life-cycle cost savings * (2020$)
0	80	1.00	0	0	0
1	82	0.98	1	33	93
2	90	0.91	14	22	80
3	95	0.86	12	38	301
4	99	0.83	13	86	664

The calculation includes consumers with zero LCC savings (no impact).
Note: TSL 0 represents the baseline.

TABLE V.6—AVERAGE LCC AND PBP RESULTS FOR RESIDENTIAL-DUTY GAS-FIRED STORAGE WATER HEATERS

TSL *	UEF **	Average costs (2020$)				Simple payback period (years)
		Installed cost	First year's operating cost	Lifetime operating cost	LCC	
0	0.59	2,219	925	12,033	14,253	
1	0.68	2,435	855	11,346	13,781	3.1
2	0.77	3,246	806	10,947	14,193	9.4

[164] Efficiency levels that were analyzed for this NOPR are discussed in section IV.C.4 of this document. Results by efficiency level are presented in TSD chapters 8, 10, and 12.

TABLE V.6—AVERAGE LCC AND PBP RESULTS FOR RESIDENTIAL-DUTY GAS-FIRED STORAGE WATER HEATERS—Continued

TSL *	UEF **	Average costs (2020$)				Simple payback period (years)
		Installed cost	First year's operating cost	Lifetime operating cost	LCC	
3	0.86	3,596	754	10,438	14,034	8.6
4	0.93	3,634	725	10,155	13,788	7.5

* The results for each TSL are calculated assuming that all consumers use equipment with that efficiency level. The PBP is measured relative to the baseline equipment.
Note: TSL 0 represents the baseline.
** The UEF shown is for the representative capacity of 75 gallons.

TABLE V.7—AVERAGE LCC SAVINGS RELATIVE TO THE NO-NEW-STANDARDS CASE FOR RESIDENTIAL-DUTY GAS-FIRED STORAGE WATER HEATERS

TSL	UEF *	Life-cycle cost savings		
		Percentage of commercial consumers that experience a net cost	Percentage of commercial consumers that experience a net benefit	Average life-cycle cost savings ** (2020$)
0	0.59	0	0	0
1	0.68	2	28	129
2	0.77	17	20	(20)
3	0.86	26	44	90
4	0.93	18	77	324

* The UEF shown is for the representative capacity of 75 gallons.
** The calculation includes consumers with zero LCC savings (no impact). A value in parentheses is a negative number.
Note: TSL 0 represents the baseline.

TABLE V.8—AVERAGE LCC AND PBP RESULTS BY EFFICIENCY LEVEL FOR GAS-FIRED TANKLESS WATER HEATERS

TSL *	Thermal efficiency (E_t) (percent)	Average costs (2020$)				Simple payback period (years)
		Installed cost	First year's operating cost	Lifetime operating cost	LCC	
0	80	2,875	597	8,338	11,213	....
1	84	2,911	572	8,052	10,964	1.6
2	94	3,490	519	7,517	11,007	9.4
3	96	3,541	510	7,401	10,942	8.9
4	96	3,541	510	7,401	10,942	8.9

* The results for each TSL are calculated assuming that all consumers use equipment with that efficiency level. The PBP is measured relative to the baseline equipment.
TSL 0 represents the baseline.

TABLE V.9— AVERAGE LCC SAVINGS RELATIVE TO THE NO-NEW-STANDARDS-CASE EFFICIENCY DISTRIBUTION FOR GAS-FIRED TANKLESS WATER HEATERS

TSL	Thermal efficiency (E_t) (percent)	Life-cycle cost savings		
		Percentage of commercial consumers that experience a net cost	Percentage of commercial consumers that experience a net benefit	Average life-cycle cost savings * (2020$)
0	80	0	0	0
1	84	0	17	42
2	94	9	8	40
3	96	12	25	63
4	96	12	25	63

* The calculation includes consumers with zero LCC savings (no impact).
Note: TSL 0 represents the baseline.

TABLE V.10—AVERAGE LCC AND PBP RESULTS BY EFFICIENCY LEVEL FOR GAS-FIRED CIRCULATING WATER HEATERS AND HOT WATER SUPPLY BOILERS

TSL *	Thermal efficiency (E_t) (percent)	Average costs (2020$)				Simple payback period (years)
		Installed cost	First year's operating cost	Lifetime operating cost	LCC	
0	80	7,714	4,449	80,795	88,509	
1	84	7,910	4,306	78,534	86,444	1.4
2	94	11,993	3,930	72,782	84,775	9.3
3	96	12,325	3,864	71,741	84,066	8.8
4	96	12,325	3,864	71,741	84,066	8.8

* The results for each TSL are calculated assuming that all consumers use equipment with that efficiency level. The PBP is measured relative to the baseline equipment.

Note: TSL 0 represents the baseline.

TABLE V.11—AVERAGE LCC SAVINGS RELATIVE TO THE NO-NEW-STANDARDS-CASE EFFICIENCY DISTRIBUTION FOR GAS-FIRED CIRCULATING WATER HEATERS AND HOT WATER SUPPLY BOILERS

TSL	Thermal efficiency (E_t) (percent)	Life-cycle cost savings		
		Percentage of commercial consumers that experience a net cost	Percentage of commercial consumers that experience a net benefit	Average life-cycle cost savings * (2020$)
0	80	0	0	0
1	84	2	15	172
2	94	11	22	702
3	96	13	36	1,047
4	96	13	36	1,047

* The calculation includes consumers with zero LCC savings (no impact).

Note: TSL 0 represents the baseline.

TABLE V.12—AVERAGE LCC AND PBP RESULTS BY EFFICIENCY LEVEL FOR GAS-FIRED INSTANTANEOUS WATER HEATERS AND HOT WATER SUPPLY BOILERS *

TSL *	Thermal efficiency (E_t) (percent)	Average costs (*2020$*)				Simple payback period (years)
		Installed cost	First year's operating cost	Lifetime operating cost	LCC	
0	80	5,512	2,696	47,826	53,338	
1	84	5,635	2,607	46,463	52,099	1.4
2	94	8,124	2,378	43,085	51,208	9.3
3	96	8,328	2,338	42,465	50,793	8.8
4	96	8,328	2,338	42,465	50,793	8.8

* This table shows results for the gas-fired instantaneous water heaters and hot water supply boilers equipment class (*i.e.,* both tankless water heaters and hot water supply boilers), and reflects a weighted average result of Tables V.8 and V.10 of this NOPR.

** The results for each TSL are calculated assuming that all consumers use equipment with that efficiency level. The PBP is measured relative to the baseline equipment.

Note: TSL 0 represents the baseline.

TABLE V.13—AVERAGE LCC SAVINGS RELATIVE TO THE NO-NEW-STANDARDS-CASE EFFICIENCY DISTRIBUTION FOR GAS-FIRED INSTANTANEOUS WATER HEATERS AND HOT WATER SUPPLY BOILERS*

TSL	Thermal efficiency (E_t) (percent)	Life-cycle cost savings		
		Percentage of commercial consumers that experience a net cost	Percentage of commercial consumers that experience a net benefit	Average life-cycle cost savings ** (2020$)
0	80	0	0	0
1	84	1	16	113
2	94	10	16	400
3	96	12	31	599
4	96	12	31	599

* This table shows results for the gas-fired instantaneous water heaters and hot water supply boilers equipment class (*i.e.,* both tankless water heaters and hot water supply boilers), and reflects a weighted average result of Tables V.9 and V.11 of this NOPR.

** The calculation includes consumers with zero LCC savings (no impact).

Note: TSL 0 represents the baseline.

b. Consumer Subgroup Analysis

In the consumer subgroup analysis, DOE estimated the impact of the considered TSLs on a low-income residential population (0–20 percentile gross annual household income) subgroup. Table V.14 through Table V.23 of this NOPR compare the average LCC savings and PBP at each efficiency level for the consumer subgroup, along with the average LCC savings for the entire consumer sample. In most cases, the average LCC savings and PBP for low-income residential consumers at the considered efficiency levels are either similar to or more favorable than the average for all consumers, due in part to greater levels of equipment usage in RECS apartment building sample identified as low-income observations when compared to the average consumer of CWH equipment. The exception is tankless water heaters in which low-income consumers' LCC savings are lower than the average of all consumers. Chapter 11 of the NOPR TSD presents the complete LCC and PBP results for the subgroup analysis.

TABLE V.14—COMPARISON OF IMPACTS FOR CONSUMER SUBGROUP WITH ALL CONSUMERS, COMMERCIAL GAS-FIRED STORAGE WATER HEATERS AND STORAGE-TYPE INSTANTANEOUS WATER HEATERS

TSL	Thermal efficiency (E_t) (percent)	Standby loss (SL) factor (percent)	LCC savings (2020$)		Simple payback period (years)	
			Residential low-income	All	Residential low-income	All
1	82	98	124	93	0.9	1.1
2	90	91	210	80	5.6	7.0
3	95	86	509	301	4.1	5.2
4	99	83	1,008	664	3.5	4.4

TABLE V.15—COMPARISON OF IMPACTED CONSUMERS FOR CONSUMER SUBGROUP AND ALL CONSUMERS, COMMERCIAL GAS-FIRED STORAGE WATER HEATERS AND STORAGE-TYPE INSTANTANEOUS WATER HEATERS

TSL	Thermal efficiency (E_t) (percent)	Standby loss (SL) factor (percent)	Percent of consumers that experience a net cost		Percent of consumers that experience a net benefit	
			Residential low-income	All	Residential low-income	All
1	82	98	0	1	34	33
2	90	91	11	14	26	22
3	95	86	7	12	42	38
4	99	83	6	13	93	86

TABLE V.16—COMPARISON OF IMPACTS FOR CONSUMER SUBGROUP WITH ALL CONSUMERS, RESIDENTIAL-DUTY GAS-FIRED STORAGE WATER HEATERS

TSL	UEF	LCC savings (2020$)		Simple payback period (years)	
		Residential low-income	All	Residential low-income	All
1	0.68	131	129	3.1	3.1
2	0.77	15	(20)	8.5	9.4
3	0.86	138	90	7.9	8.6
4	0.93	383	324	6.9	7.5

* Parentheses indicate negative values.

TABLE V.17—COMPARISON OF IMPACTED CONSUMERS FOR CONSUMER SUBGROUP AND ALL CONSUMERS, RESIDENTIAL-DUTY GAS-FIRED STORAGE WATER HEATERS

TSL	UEF	Percent of consumers that experience a net cost		Percent of consumers that experience a net benefit	
		Residential low-income	All	Residential low-income	All
1	0.68	1	2	29	28
2	0.77	15	17	22	20
3	0.86	22	26	47	44
4	0.93	14	18	81	77

TABLE V.18—COMPARISON OF IMPACTS FOR CONSUMER SUBGROUP WITH ALL CONSUMERS, GAS-FIRED TANKLESS WATER HEATERS

TSL	Thermal efficiency (E_t) (percent)	LCC savings (2020$)		Simple payback period (years)	
		Residential low-income	All	Residential low-income	All
1	84	25	42	2.8	1.6
2	94	11	40	13.2	9.4
3	96	21	63	12.7	8.9
4	96	21	63	12.7	8.9

TABLE V.19—COMPARISON OF IMPACTED CONSUMERS FOR CONSUMER SUBGROUP AND ALL CONSUMERS, GAS-FIRED TANKLESS WATER HEATERS

TSL	Thermal efficiency (E_t) (percent)	Percent of consumers that experience a net cost		Percent of consumers that experience a net benefit	
		Residential low-income	All	Residential low-income	All
1	84	0	0	17	17
2	94	11	9	6	8
3	96	16	12	22	25
4	96	16	12	22	25

TABLE V.20—COMPARISON OF IMPACTS FOR CONSUMER SUBGROUP WITH ALL CONSUMERS, GAS-FIRED CIRCULATING WATER HEATERS AND HOT WATER SUPPLY BOILERS

TSL	Thermal efficiency (E_t) (percent)	LCC savings (2020$)		Simple payback period (years)	
		Residential low-income	All	Residential low-income	All
1	84	265	172	1.1	1.4
2	94	2,029	702	6.7	9.3
3	96	2,754	1,047	6.3	8.8
4	96	2,754	1,047	6.3	8.8

TABLE V.21—COMPARISON OF IMPACTED CONSUMERS FOR CONSUMER SUBGROUP AND ALL CONSUMERS, GAS-FIRED CIRCULATING WATER HEATERS AND HOT WATER SUPPLY BOILERS

TSL	Thermal efficiency (E_t) (percent)	Percent of consumers that experience a net cost		Percent of consumers that experience a net benefit	
		Residential low-income	All	Residential low-income	All
1	84	1	2	15	15
2	94	6	11	28	22
3	96	6	13	43	36
4	96	6	13	43	36

TABLE V.22—COMPARISON OF IMPACTS FOR CONSUMER SUBGROUP WITH ALL CONSUMERS, GAS-FIRED INSTANTANEOUS WATER HEATERS AND HOT WATER SUPPLY BOILERS *

TSL	Thermal efficiency (E_t) (percent)	LCC savings (2020$)		Simple payback period (years)	
		Residential low-income	All	Residential low-income	All
1	84	156	113	1.2	1.4
2	94	1,111	400	7.0	9.3
3	96	1,511	599	6.5	8.8
4	96	1,511	599	6.5	8.8

* This table shows results for the gas-fired instantaneous water heaters and hot water supply boilers equipment class (*i.e.,* both tankless water heaters and hot water supply boilers), and reflects a weighted average result of Tables V.18 and V.20 of this NOPR.

TABLE V.23—COMPARISON OF IMPACTED CONSUMERS FOR CONSUMER SUBGROUP AND ALL CONSUMERS, GAS-FIRED INSTANTANEOUS WATER HEATERS AND HOT WATER SUPPLY BOILERS *

TSL	Thermal efficiency (E_t) (percent)	Percent of consumers that experience a net cost		Percent of consumers that experience a net benefit	
		Residential low-income	All	Residential low-income	All
1	84	1	1	16	16
2	94	8	10	18	16
3	96	10	12	33	31
4	96	10	12	33	31

* This table shows results for the gas-fired instantaneous water heaters and hot water supply boilers equipment class (*i.e.,* both tankless water heaters and hot water supply boilers), and reflects a weighted average result of Tables V.19 and V.21 of this NOPR.

c. Rebuttable Presumption Payback

As discussed in section I.A.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 PBP for each of the considered TSLs, DOE used discrete values, and, as required by EPCA, based the energy use calculation on the DOE test procedure for CWH equipment. In contrast, the PBPs presented in section V.B.1.a were calculated using distributions that reflect the range of energy use in the field. Table V.24 presents rebuttable presumption payback period results. TSL 1 is the only level at which the rebuttable presumption payback periods are less than or equal to three. See chapter 8 of the NOPR TSD for more information on the rebuttable presumption payback analysis.

TABLE V.24—REBUTTABLE PRESUMPTION PAYBACK PERIODS

Equipment	Trial standard level (years)			
	1	2	3	4
Commercial Gas-Fired Storage and Storage-Type Instantaneous Water Heaters	1.1	6.8	4.9	4.3
Residential Duty Gas-Fired Storage	3.1	8.6	8.1	7.1
Gas-Fired Instantaneous Water Heaters and Hot Water Supply Boilers	1.4	8.2	7.9	7.9
Instantaneous, Gas-Fired Tankless	1.5	7.9	7.7	7.7
Instantaneous Water Heaters and Hot Water Supply Boilers	1.4	8.2	7.9	7.9

2. Economic Impacts on Manufacturers

DOE performed an MIA to estimate the impact of amended energy conservation standards on manufacturers of CWH equipment. 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 standard. Table V.25 through Table V.28 of this NOPR summarize the estimated financial impacts of potential amended energy conservation standards on manufacturers of CWH equipment, as well as the conversion costs that DOE estimates manufacturers of CWH equipment would incur at each TSL.

The impact of potential amended energy conservation standards was analyzed under two markup scenarios: (1) The preservation of gross margin percentage markup scenario and (2) the preservation of per-unit operating profit markup scenario, as discussed in section IV.J.2.d of this document. The preservation of gross margin percentage scenario provides the upper bound while the preservation of operating profits scenario results in the lower (or more severe) bound to impacts of potential amended standards on industry.

Each of the modeled scenarios results in a unique set of cash flows and corresponding INPV for each TSL. INPV is the sum of the discounted cash flows to the industry from the base year through the end of the analysis period (2020–2055). The ''change in INPV'' results refer to the difference in industry value between the no-new-standards case and standards case at each TSL. To provide perspective on the short-run cash flow impact, DOE includes a comparison of free cash flow between the no-new-standards case and the standards case at each TSL in the year before amended standards would take effect. This 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 and product designs into compliance with potential amended standards. As described in section IV.J.2.c of this document, conversion cost investments occur between the year of publication of the final rule and the year by which manufacturers must comply with the new standard. The conversion costs can have a significant impact on the short-term cash flow on the industry and generally result in lower free cash flow in the period between the publication of the final rule and the compliance date of potential amended standards. Conversion costs are independent of the manufacturer markup scenarios and are not presented as a range in this analysis.

The results in Table V.25 through Table V.28 of this NOPR show potential INPV impacts for CWH equipment manufacturers by equipment class. The tables present the range of potential impacts reflecting both the less severe set of potential impacts (preservation of gross margin) and the more severe set of potential impacts (preservation of per-unit operating profit). In the following discussion, the INPV results refer to the difference in industry value between the no-new-standards case and each standards case that results from the sum of discounted cash flows from 2020 (the base year) through 2055 (the end of the analysis period).

To provide perspective on the near-term cash flow impact, DOE discusses the change in free cash flow between the no-new-standards case and the standards case at each TSL in the year before new standards take effect. These figures provide an understanding of the magnitude of the required conversion costs at each TSL relative to the cash flow generated by the industry in the no-new-standards case.

1. Industry Cash Flow for Commercial Gas-Fired Storage Water Heaters and Storage-Type Instantaneous Equipment

TABLE V.25—MANUFACTURING IMPACT ANALYSIS RESULTS FOR COMMERCIAL GAS-FIRED STORAGE WATER HEATERS AND STORAGE-TYPE INSTANTANEOUS WATER HEATERS

	Units	No-new-standards case	Trial standard level			
			1	2	3	4
INPV	2020$ millions	134.6	133.5–133.9	127.8–130.4	121.1–125.1	70.1–76.6
Change in INPV	2020$ millions		(1.1)–(0.7)	(6.8)–(4.2)	(13.5)–(9.5)	(64.5)–(58.0)
	%		(0.8)–(0.5)	(5.1)–(3.1)	(10.0)–(7.0)	(47.9)–(43.1)
Free Cash Flow (2025)	2020$ millions	10.9	10.2	6.6	2.6	31.8
Change in Free Cash Flow	2020$ millions		(0.7)	(4.3)	(8.3)	(42.7)
	%		(6.2)	(39.3)	(75.8)	(391.4)
Product Conversion Costs	*2020$ millions*		1.9	5.3	11.6	82.1
Capital Conversion Costs	*2020$ millions*		0.0	5.4	9.2	19.5
Total Conversion Costs	*2020$ millions*		1.9	10.6	20.8	101.5

At TSL 1, DOE estimates impacts on INPV for commercial gas-fired storage and storage-type instantaneous water heater equipment manufacturers to range from −0.8 percent to −0.5 percent, or a change of −$1.1 million to −$0.7 million. At this level, DOE estimates that industry free cash flow would decrease by approximately 6.2 percent to $10.2 million, compared to the no-new-standards-case value of $10.9 million in the year before compliance (2025).

DOE estimates 70 percent of commercial gas-fired storage water heater and storage-type instantaneous water heater basic models meet or exceed the thermal efficiency and standby loss standards at TSL 1. DOE does not expect the modest increases in thermal efficiency and standby loss requirements at this TSL to require major equipment redesigns or large capital investments. Overall, DOE estimates that manufacturers would incur $1.9 million in product conversion costs and $0.03 million in capital conversion costs to bring their equipment portfolios into compliance with a standard set to TSL 1. At TSL 1, conversion costs are a key driver of results. These upfront investments result in a lower INPV in both manufacturer markup scenarios.

At TSL 2, DOE estimates impacts on INPV for manufacturers of this equipment class to range from −5.1 percent to −3.1 percent, or a change in INPV of −$6.8 million to −$4.2 million. At this potential standard level, industry free cash flow would decrease by approximately 39.3 percent to $6.6 million, compared to the no-new-standards case value of $10.9 million in the year before compliance (2025).

DOE estimates 41 percent of commercial gas-fired storage water heater and storage-type instantaneous water heater basic models meet or exceed the thermal efficiency and standby loss standards at TSL 2. Product and capital conversion costs would increase at this TSL as manufacturers update designs and production equipment to meet a thermal efficiency standard that necessitates condensing technology. DOE notes that capital investment would vary by manufacturers due to differences in condensing heat exchanger designs and differences in existing production capacity. These capital conversion costs include, but are not limited to, investments in tube bending, press dies, machining, enameling, MIG welding, leak testing, quality assurance stations, and conveyer.

DOE estimates that manufacturers would incur $5.3 million in product conversion costs and $5.4 million in capital conversion costs to bring their offered commercial gas-fired storage water heaters and storage-type instantaneous water heaters into compliance with a standard set to TSL 2. At TSL 2, conversion costs are a key driver of results. These upfront investments result in a lower INPV in both manufacturer markup scenarios.

At TSL 3, DOE estimates impacts on INPV for commercial gas-fired storage water heater and storage-type instantaneous water heater manufacturers to range from −10.0 percent to −7.0 percent, or a change in INPV of −$13.5 million to −$9.5 million. At this potential standard level, DOE estimates industry free cash flow would decrease by approximately 75.8 percent to $2.6 million, compared to the no-new-standards-case value of $10.9 million in the year before compliance (2025).

DOE estimates that 34 percent of currently offered commercial gas-fired storage water heater and storage-type instantaneous water heater basic models meet or exceed the thermal efficiency and standby loss standards at TSL 3. At this level, DOE estimates that product conversion costs would increase, as manufacturers would have to redesign a larger percentage of their offerings to meet the higher thermal efficiency levels. Additionally, capital conversion costs would increase, as manufacturers upgrade their laboratories and test facilities to increase capacity for product development and safety testing for their commercial gas-fired storage water heater and storage-type instantaneous water heater offerings. Overall, DOE estimates that manufacturers would incur $11.6 million in product conversion costs and $9.2 million in capital conversion costs to bring their commercial gas-fired storage water heater and storage-type instantaneous water heater portfolio into compliance with a standard set to TSL 3. At TSL 3, conversion costs are a key driver of results. These upfront investments result in a lower INPV in both manufacturer markup scenarios.

TSL 4 represents the max-tech thermal efficiency and standby loss levels. At TSL 4, DOE estimates impacts on INPV for commercial gas-fired storage water heater and storage-type instantaneous water heater manufacturers to range from −47.9 percent to −43.1 percent, or a change in INPV of −$64.5 million to −$58.0 million. At this TSL, DOE estimates industry free cash flow in the year before compliance (2025) would decrease by approximately 391 percent to −$31.8 million compared to the no-new-standards case value of $10.9 million.

The impacts on INPV at TSL 4 are significant. DOE estimates less than 1 percent of currently offered basic models meet or exceed the efficiency levels prescribed at TSL 4. DOE expects product conversion costs to be significant at TSL 4, as almost all equipment on the market would have to be redesigned. Furthermore, the redesign process would be more resources intensive and costly at TSL 4 than at other TSLs. Traditionally, manufacturers design their equipment platforms to support a range of models with varying input capacities and storage volumes, and the efficiency typically will vary slightly between models within a given platform. However, at TSL 4, manufacturers would be limited in their ability to maintain a platform approach to designing commercial gas-fired storage and storage-type instantaneous water heaters, because the 99 percent thermal efficiency level represents the maximum achievable efficiency and there would be no allowance for slight variations in efficiency between individual models. At TSL 4, manufacturers would be required to separately redesign each individual model to optimize performance for each specific input capacity and storage volume combination. In manufacturer interviews, some manufacturers raised concerns that they would not have sufficient engineering capacity to complete necessary redesigns within the 3-year conversion period. If manufacturers require more than 3 years to redesign all models, they would likely prioritize redesigns based on sales volume. Due to the increase in number of redesigns and engineering effort, DOE estimates that product conversion costs would increase to $82.1 million.

DOE estimates that manufacturers would also incur $19.5 million in capital conversion costs. In addition to upgrading production lines, DOE expects manufacturers would need to add laboratory space to develop and test products to meet amended standards at TSL 4 standards. These large upfront investments result in a lower INPV in both manufacturer markup scenarios.

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

2. Industry Cash Flow for Residential-Duty Gas-Fired Storage Water Heaters

TABLE V.26—MANUFACTURING IMPACT ANALYSIS RESULTS FOR RESIDENTIAL DUTY GAS-FIRED STORAGE WATER HEATERS

	Units	No-new-standards case	Trial standard level			
			1	2	3	4
INPV	*2020$ millions*	10.1	9.8–10.1	9.2–9.9	8.4–10.6	5.7–8.1
Change in INPV	*2020$ millions*		(0.3)–0.0	(0.9)–(0.2)	(1.7)–0.5	(4.5)–(2.0)
	%		(3.0)–0.0	(8.7)–(2.4)	(16.5)–5.4	(44.0)–(19.7)
Free Cash Flow (2025)	*2020$ millions*	0.8	0.6	0.3	(0.02)	(1.9)
Change in Free Cash Flow	*2020$ millions*		(0.2)	(0.5)	(0.8)	(2.7)
	%		(21.4)	(59.7)	(102.7)	(335.2)
Product Conversion Costs	*2020$ millions*		0.5	0.7	1.2	4.6
Capital Conversion Costs	*2020$ millions*		0.0	0.5	0.9	1.9
Total Conversion Costs	*2020$ millions*		0.5	1.2	2.1	6.5

At TSL 1, DOE estimates impacts on INPV for residential-duty gas-fired storage equipment manufacturers to range from −3.0 percent to less than one percent, or a change of −$0.3 million to less than 0.1 million. At this level, DOE estimates that industry free cash flow would decrease by approximately 21.4 percent to $0.6 million, compared to the no-new-standards-case value of $0.8 million in the year before compliance (2025).

DOE estimates that 53 percent of currently offered residential-duty gas-fired storage water heater basic models already meet or exceed the UEF standards at TSL 1. DOE does not expect the modest increases in UEF requirements at this TSL to require major equipment redesigns or large capital investments. Overall, DOE estimates that manufacturers would incur $0.5 million in product conversion costs and $0.03 million in capital conversion costs to bring their residential-duty commercial gas-fired storage equipment portfolios into compliance with a standard set to TSL 1. At TSL 1, conversion costs are the primary driver of results. These upfront investments result in a lower INPV in both manufacturer markup scenarios.

At TSL 2, DOE estimates impacts on INPV for manufacturers of this equipment class to range from −8.7 percent to −2.4 percent, or a change in INPV of −$0.9 million to −$0.2 million. At this potential standard level, industry free cash flow would decrease by approximately 59.7 percent to $0.3 million, compared to the no-new-standards case value of $0.8 million in the year before compliance (2025).

DOE estimates that 38 percent of currently offered residential-duty gas-fired storage water heater basic models would already meet or exceed the UEF standards at TSL 2. DOE estimates that product and capital conversion costs would increase at this TSL. Manufacturers would meet the UEF levels for residential-duty commercial gas-fired storage equipment by shifting to condensing technology. DOE notes that the capital investment would vary by manufacturers due to differences in condensing heat exchanger designs and differences in existing production capacity.

DOE estimates that manufacturers would incur $0.7 million in product conversion costs and $0.5 million in capital conversion costs to bring their residential-duty gas-fired storage water heaters into compliance with a standard set to TSL 2. At TSL 2, conversion costs continue to be the primary driver of results. These upfront investments result in a lower INPV in both manufacturer markup scenarios.

At TSL 3, DOE estimates impacts on INPV for residential-duty gas-fired manufacturers to range from −16.5 percent to 5.4 percent, or a change in INPV of −$1.7 million to $0.5 million. At this potential standard level, DOE estimates industry free cash flow would decrease by approximately 102.7 percent to −$0.02 million compared to the no-new-standards-case value of $0.8 million in the year before compliance (2025).

The impacts on INPV at TSL 3 are slightly more negative at the lower bound than at TSL 2. Unlike TSL 2, at the upper bound, INPV impacts are positive. DOE estimates that 22 percent of currently offered residential-duty commercial gas-fired storage water heater basic models would meet or exceed the UEF standards at TSL 3. At this level, DOE estimates that product conversion costs would increase, as manufacturers would have to redesign a larger percentage of their offerings to meet the higher UEF levels. Additionally, capital conversion costs would increase, as manufacturers increase production capacity for condensing equipment. Overall, DOE estimates that manufacturers would incur $1.2 million in product conversion costs and $0.9 million in capital conversion costs to bring their residential-duty commercial gas-fired storage water heater portfolio into compliance with a standard set to TSL 3. At TSL 3, conversion costs are a key driver of results.

TSL 4 represents the max-tech UEF levels. At TSL 4, DOE estimates impacts on INPV for residential-duty commercial gas-fired storage water heater manufacturers to range from −44.0 percent to −19.7 percent, or a change in INPV of −$4.5 million to −$2.0 million. At this TSL, DOE estimates industry free cash flow in the year before compliance (2025) would decrease by approximately 335.2 percent to −$1.9 million compared to the no-new-standards case value of $0.8 million.

The impacts on INPV at TSL 4 are significant. DOE estimates that less than 5 percent of currently offered residential-duty gas-fired water heater equipment meet or exceed the efficiency levels prescribed at TSL 4. DOE expects conversion costs to be significant at TSL 4, as most equipment currently on the market would have to be redesigned and new products would have to be developed to meet a wider range of storage volumes. DOE estimates that product conversion costs would increase to $4.6 million, as manufacturers would have to redesign a much larger percentage of their offerings to meet max-tech.

DOE estimates that manufacturers would also incur $1.9 million in capital conversion costs. In addition to upgrading production lines, DOE accounted for the costs to add laboratory space to develop and safety test products that meet max-tech efficiency levels. At TSL 4, conversion costs are high. These upfront investments result in a lower INPV in both manufacturer markup scenarios.

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

3. Industry Cash Flow for Gas-Fired Instantaneous Tankless Water Heaters

TABLE V.27—MANUFACTURING IMPACT ANALYSIS RESULTS FOR GAS-FIRED INSTANTANEOUS TANKLESS WATER HEATERS

	Units	No-new-standards case	Trial standard level			
			1	2	3	4
INPV	*2020$ millions*	7.1	6.8–6.8	6.1–6.2	6.1–6.3	6.1–6.3
Change in INPV	*2020$ millions*		(0.3)–(0.3)	(1.0)–(0.9)	(1.1)–(0.8)	(1.1)–(0.8)
	%		(4.5)–(4.2)	(14.8)–(12.6)	(15.0)–(11.8)	(15.0)–(11.8)
Free Cash Flow (2025)	*2020$ millions*	0.5	0.3	(0.2)	(0.2)	(0.2)
Change in Free Cash Flow	*2020$ millions*		(0.2)	(0.7)	(0.7)	(0.7)
	%		(43.2)	(143.2)	(143.3)	(143.3)
Product Conversion Costs	*2020$ millions*		0.6	1.2	1.2	1.2
Capital Conversion Costs	*2020$ millions*		0.0	0.6	0.6	0.6
Total Conversion Costs	*2020$ millions*		0.6	1.8	1.8	1.8

At TSL 1, DOE estimates impacts on INPV for gas-fired instantaneous tankless water heaters manufacturers to range from −4.5 percent to −4.2 percent, or a change of approximately −$0.3 million. At this level, DOE estimates that industry free cash flow would decrease by approximately 43.2 percent to $0.3 million, compared to the no-new-standards-case value of $0.5 million in the year before compliance (2025).

DOE estimates that 84 percent of basic models of gas-fired instantaneous tankless water heaters already meet or exceed the thermal efficiency standards at TSL 1. At this level, DOE expects manufacturers of this equipment class to incur product conversion costs to redesign their equipment. DOE does not expect the modest increases in thermal efficiency requirements at this TSL to require capital investments. Overall, DOE estimates that manufacturers would incur $0.6 million in product conversion costs and no capital conversion costs to bring this equipment portfolio into compliance with a standard set to TSL 1. At TSL 1, product conversion costs are the key driver of results. These upfront investments result in a lower INPV in both manufacturer markup scenarios.

At TSL 2, DOE estimates impacts on INPV ranges from −14.8 percent to −12.6 percent, or a change in INPV of −$1.0 million to −$0.9 million. At this potential standard level, DOE estimates industry free cash flow to decrease by approximately 143.2 percent to −$0.21 million compared to the no-new-standards-case value of $0.5 million in the year before compliance (2025).

DOE estimates that 84 percent of basic models of gas-fired instantaneous tankless water heaters already meet or exceed the thermal efficiency standards at TSL 2. DOE estimates that product and capital conversion costs would increase at this TSL. Manufacturers would meet the thermal efficiency levels by using condensing technology. DOE understands that tankless water heater manufacturers produce far more consumer products in significantly higher volumes than commercial offerings, and that these products are manufactured in the same facilities with shared production lines. DOE expects manufacturers would need to make incremental investments rather than setup new production lines. Overall, DOE estimates that manufacturers would incur $1.2 million in product conversion costs and $0.6 million in capital conversion costs to bring their instantaneous gas-fired tankless wat heater portfolio into compliance with a standard set to TSL 2.

As discussed in section IV.A of this document, TSL 3 and TSL 4 represent max-tech thermal efficiency levels for gas-fired instantaneous tankless water heaters. Therefore, DOE modeled identical impacts to manufacturers of this equipment for both TSL 3 and TSL 4. At these levels, DOE estimates impacts on INPV to range from −15.0 percent to −11.8 percent, or a change in INPV of −$1.1 million to −$0.8 million. At these levels, DOE estimates industry free cash flow in the year before compliance (2025) would decrease by approximately 143.3 percent to −$0.2 million compared to the no-new-standards case value of $0.5 million. DOE estimates that 53 percent of basic models of efficiency standards at TSL 3 and TSL 4.

DOE anticipates modest product conversion costs as manufacturers continue to increase their offerings at greater input capacities. Overall, DOE estimates that manufacturers would incur $1.2 million in product conversion costs and $0.6 million in capital conversion costs to bring their gas-fired instantaneous tankless portfolio into compliance with a standard set to TSL 3 and TSL 4.

4. Industry Cash Flow for Instantaneous Circulating Water Heaters and Hot Water Supply Boilers

TABLE V.28—MANUFACTURING IMPACT ANALYSIS RESULTS FOR CIRCULATING WATER HEATERS AND HOT WATER SUPPLY BOILERS

	Units	No-new-standards case	Trial standard level			
			1	2	3	4
INPV	2020$ millions	31.3	31.1–31.3	28.0–33.2	24.0–30.2	24.0–30.2
Change in INPV	2020$ millions		(0.2)–(0.0)	(3.3)–1.9	(7.3)–(1.1)	(7.3)–(1.1)
	%		(0.5)–(0.1)	(10.5)–5.9	(23.2)–(3.4)	(23.2)–(3.4)
Free Cash Flow (2025)	2020$ millions	2.1	2.0	0.6	(1.8)	(1.8)
Change in Free Cash Flow	2020$ millions		(0.1)	(1.5)	(3.9)	(3.9)
	%		(4.1)	(71.3)	(187.5)	(187.5)
Product Conversion Costs	2020$ millions		0.2	1.8	8.1	8.1
Capital Conversion Costs	2020$ millions		0.0	1.9	1.9	1.9
Total Conversion Costs	2020$ millions		0.2	3.6	10.0	10.0

At TSL 1, DOE estimates impacts on INPV for instantaneous circulating water heater and hot water supply boiler manufacturers to range from −0.5 percent to −0.1 percent, or a change of −$0.1 million to less than −0.1 million. At this level, DOE estimates that industry free cash flow would decrease by approximately 4.1 percent to $2.0 million, compared to the no-new-standards-case value of $2.1 million in the year before compliance (2025).

DOE estimates that 62 percent of basic models of this equipment class already meet or exceed the thermal efficiency standards at TSL 1. At this level, DOE expects manufacturers of this equipment class to incur product conversion costs to redesign their equipment. DOE does not expect the modest increases in thermal efficiency requirements at this TSL to require capital investments. Overall, DOE estimates that manufacturers would incur $0.2 million in product conversion costs and no capital conversion costs to bring this equipment portfolio into compliance with a standard set to TSL 1. At TSL 1, product conversion costs are the key driver of results. These upfront investments result in a slightly lower INPV in both manufacturer markup scenarios.

At TSL 2, DOE estimates impacts on INPV ranges from −10.5 percent to 5.9 percent, or a change in INPV of −$3.3 million to $1.9 million. At this potential standard level, DOE estimates industry free cash flow to decrease by approximately 71.3 percent to $0.6 million compared to the no-new-standards-case value of $2.1 million in the year before compliance (2025).

The impacts on INPV at TSL 2 remain similar to TSL 1. DOE estimates that 36 percent of basic models of this equipment class already meet or exceed the thermal efficiency standards at TSL 2. DOE estimates that product and capital conversion costs would increase at this TSL. Manufacturers would meet the thermal efficiency levels by using condensing technology. DOE anticipates that manufacturers will begin to incur some product conversion costs associated with design changes to reach condensing levels. Additionally, DOE anticipates manufacturers achieving condensing levels with additional purchased parts (*i.e.,* condensing heat exchanger, burner tube, blower, gas valve). DOE's capital conversion costs reflect the incremental warehouse space required to store these additional purchased parts.

Overall, DOE estimates that manufacturers would incur $1.8 million in product conversion costs and $1.9 million in capital conversion costs to bring their instantaneous circulating water heater and hot water supply boiler portfolio into compliance with a standard set to TSL 2.

As discussed in section IV.A of this document, TSL 3 and TSL 4 represent max-tech thermal efficiency levels for circulating water heater and hot water supply boiler equipment. Therefore, DOE modeled identical impacts to manufacturers of this equipment for both TSL 3 and TSL 4. At these levels, DOE estimates impacts on INPV to range from −23.2 percent to −3.4 percent, or a change in INPV of −$7.3 million to −$1.1 million. DOE estimates industry free cash flow in the year before compliance (2025) would decrease by approximately 187.5 percent to −$1.8 million compared to the no-new-standards case value of $2.1 million. DOE estimates that 27 percent of basic models of this equipment class already meet or exceed the max-tech thermal efficiency standards at these TSLs.

b. Impacts on Direct Employment

To quantitatively assess the potential impacts of amended energy conservation standards on direct employment in the CWH equipment industry, DOE typically uses the GRIM to estimate the domestic labor expenditures and number of direct employees in the no-new-standards case and in each of the standards cases during the analysis period. This analysis includes both production and non-production employees employed by CWH equipment manufacturers. DOE used statistical data from the U.S. Census Bureau's 2018–2019 Annual Survey of Manufacturers [165] (ASM), the results of the engineering analysis, and interviews with manufacturers to determine the inputs necessary to calculate industry-wide labor expenditures and domestic employment levels. Labor expenditures related to manufacturing of the product are a function of the labor intensity of the product, the sales volume, and an assumption that wages remain fixed in real terms over time.

The total labor expenditures in the GRIM are converted to domestic production worker employment levels by dividing production labor expenditures by the average fully burden wage per production worker. DOE calculated the fully burdened wage by multiplying the industry production worker hourly blended wage (provided by the ASM) by the fully burdened wage ratio. The fully burdened wage ratio factors in paid leave, supplemental pay, insurance, retirement and savings, and legally required benefits. DOE determined the fully burdened ratio from the Bureau of Labor Statistic's employee compensation data.[166] The estimates of production workers in this section cover workers, including line-supervisors who are directly involved in fabricating and assembling a product within the manufacturing facility. Workers performing services that are closely associated with production operations, such as materials handling tasks using forklifts, are also included as production labor.

Non-production worker employment levels were determined by multiplying the industry ratio of production worker employment to non-production employment against the estimated production worker employment explained above. Estimates of non-production workers in this section cover above the line supervisors, sales, sales delivery, installation, office functions, legal, and technical employees.

The total direct employment impacts calculated in the GRIM are the sum of the changes in the number of domestic production and non-production workers resulting from the amended energy conservation standards for CWH equipment, as compared to the no-new-standards case. Typically, more efficient equipment is more complex and labor intensive to produce. Per-unit labor requirements and production time requirements trend higher with more stringent energy conservation standards.

DOE estimates that 93 percent of CWH equipment sold in the United States is currently manufactured domestically. In the absence of amended energy conservation standards, DOE estimates that there would be 217 domestic production workers in the CWH industry in 2026, the year of compliance.

DOE's analysis forecasts that the industry will employ 382 production and non-production workers in the CWH industry in 2026 in the absence of amended energy conservation standards. Table V.29 presents the range of potential impacts of amended energy conservation standards on U.S. production workers of CWH equipment.

TABLE V.29—CWH DIRECT EMPLOYMENT IN 2026 POTENTIAL CHANGES IN THE TOTAL NUMBER OF CWH EQUIPMENT PRODUCTION WORKERS IN DIRECT EMPLOYMENT IN 2026

	No-new-standards case	1	2	3	4
Number of Domestic Production Workers	217	218	214	219	223
Number of Domestic Non-Production Workers	165	166	163	167	170
Total Domestic Direct Employment **	382	384	377	386	393
Changes in Direct Employment	....	2	(5)	4	11

* Numbers in parentheses indicate negative numbers.
** This field presents impacts on domestic direct employment, which aggregates production and non-production workers. Based on ASM census data, DOE assumed the ratio of production to non-production employees stays consistent across all analyzed TSLs, which is 43 percent non-production workers.

In NOPR interviews conducted ahead of the 2016 NOPR notice, several manufacturers that produce high-efficiency CWH equipment stated that a standard that went to condensing levels could cause them to hire more employees to increase their production capacity. Others stated that a condensing standard would require additional engineers to redesign CWH equipment and production processes. Due different variations in manufacturing labor practices, actual direct employment could vary depending on manufacturers' preference for high capital or high labor practices in response to amended standards. DOE notes that the employment impacts discussed here are independent of the indirect employment impacts to the broader U.S. economy, which are documented in chapter 15 of the accompanying TSD.

c. Impacts on Manufacturing Capacity

At the time of manufacturer interviews (conducted ahead of the

[165] U.S. Census Bureau, 2018–2019 Annual Survey of Manufacturers: Statistics for Industry Groups and Industries (2019) (Available at *https://www.census.gov/data/tables/time-series/econ/asm/2018-2019-asm.html*).

[166] U.S. Bureau of Labor Statistics. Employer Costs for Employee Compensation. June 17, 2021. Available at: *www.bls.gov/news.release/pdf/ecec.pdf*.

withdrawn May 2016 CWH ECS NOPR), industry feedback indicated that the average CWH equipment manufacturer's current production was running at approximately 60-percent capacity. However, some manufacturers did express concerns about engineering and laboratory constraints if standards were set at condensing levels.

At TSL 4 (max-tech), this issue is exacerbated due to the proliferation of re-designs required. As discussed in further detail in section IV.J.2.c of this document, DOE anticipates manufacturers would incur significant product conversion costs for all gas-fired storage water heaters, gas-fired circulating water heaters, and hot water supply boilers. Because of the high conversion costs as this level, some manufacturers may not have the capacity to redesign the full range of equipment offerings in the 3-year conversion period. Instead, manufacturers would likely choose to offer a reduced selection of models to limit upfront investments.

Furthermore, none of the three largest manufacturers of commercial gas storage water heaters produces equipment that can meet the TE standard at TSL 4. Currently, only two models from a single manufacturer can meet the TE standard at TSL 4. This manufacturer is a small business and does not have the production capacity to meet the demand for the entire industry's shipments. Similarly, for residential-duty gas-fired storage water heaters, only one manufacturer offers models that can meet the UEF standard at TSL 4.

Issue 10: DOE seeks comment on whether manufacturers expect manufacturing capacity constraints would limit equipment availability to customers in the timeframe of the amended standard compliance date (2026).

d. Impacts on Subgroups of Manufacturers

Small manufacturers, niche equipment manufacturers, and manufacturers exhibiting a cost structure substantially different from the industry average could be affected disproportionately. Using average cost assumptions developed for an industry cash-flow estimate is inadequate to assess differential impacts among manufacturer subgroups.

For the CWH equipment industry, DOE identified and evaluated the impact of amended energy conservation standards on one subgroup—small manufacturers. The SBA defines a ''small business'' as having 1,000 employees or fewer for NAICS code 333318, ''Other Commercial and Service Industry Machinery Manufacturing.'' Based on this definition, DOE identified 3 small, domestic manufacturers of the covered equipment that would be subject to amended standards.

For a discussion of the impacts on the small manufacturer subgroup, see the regulatory flexibility analysis in section VI.B of this document and chapter 12 of the NOPR TSD.

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.

TABLE V.30—COMPLIANCE DATES AND EXPECTED CONVERSION EXPENSES OF FEDERAL ENERGY CONSERVATION STANDARDS AFFECTING COMMERCIAL WATER HEATER MANUFACTURERS

Federal energy conservation standard	Number of manufacturers *	Number of manufacturers potentially impacted by finalized rule **	Approx. standards year	Industry conversion costs millions ($)	Industry conversion costs/product revenue ***
Commercial Warm Air Furnaces; 81 FR 2420 (January 15, 2016)	14	2	2023	7.5–22.2 (2014$)	1.7%–5.1% †
Residential Central Air Conditioners and Heat Pumps; 82 FR 1786 (January 6, 2017)	30	3	2023	342.6 (2015$)	0.5%

* This column presents the total number of manufacturers identified in the energy conservation standard rule contributing to cumulative regulatory burden.

** This column presents the number of manufacturers producing CWH equipment that are also listed as manufacturers in the listed energy conservation standard contributing to cumulative regulatory burden.

*** This column presents industry conversion costs as a percentage of product revenue during the conversion period. Industry conversion costs are the upfront investments manufacturers must make to sell compliant products/equipment. The revenue used for this calculation is the revenue from just the covered product/equipment associated with each row. The conversion period is the time frame over which conversion costs are made and lasts from the announcement year of the final rule to the standards year of the final rule. The conversion period typically ranges from 3 to 5 years, depending on the energy conservation standard.

† Low and high conversion cost scenarios were analyzed as part of this Direct Final Rule. The range of estimated conversion expenses presented here reflects those two scenarios.

Issue 11: DOE requests information regarding the impact of cumulative regulatory burden on manufacturers of CWH equipment associated with multiple DOE standards or product-specific regulatory actions of other Federal agencies. Additionally, where industry-wide constraints exist as a result of other overlapping regulatory actions, DOE requests stakeholders help identify and quantify those constraints.

3. National Impact Analysis

This section presents DOE's estimates of the NES and the NPV of consumer benefits that would result from each of the TSLs considered as potential amended standards.

a. Significance of Energy Savings

To estimate the energy savings attributable to potential amended standards for CWH equipment, DOE compared their energy consumption under the no-new-standards case to their anticipated energy consumption under each TSL. The savings are measured over the entire lifetime of equipment purchased in the 30-year period that begins in the year of anticipated compliance with amended standards (2026–2055). Table V.31 presents DOE's projections of the NES for each TSL considered for CWH equipment. The savings were calculated using the approach described in section IV.H of this document.

TABLE V.31—CUMULATIVE NATIONAL ENERGY SAVINGS FOR CWH EQUIPMENT; 30 YEARS OF SHIPMENTS
[2026–2055]

	Trial standard level (quads)			
	1	2	3	4
Primary Energy:				
Commercial gas-fired storage and storage-type instantaneous	0.04	0.19	0.30	0.51
Residential duty gas-fired storage	0.01	0.03	0.06	0.09
Instantaneous gas-fired tankless	0.00	0.01	0.02	0.02
Instantaneous circulating water heaters and hot water supply boilers	0.02	0.21	0.26	0.26
Total Primary Energy	0.08	0.44	0.64	0.87
FFC Energy:				
Commercial gas-fired storage and storage-type instantaneous	0.04	0.21	0.33	0.56
Residential duty gas-fired storage	0.02	0.03	0.07	0.10
Instantaneous gas-fired tankless	0.00	0.01	0.02	0.02
Instantaneous circulating water heaters and hot water supply boilers	0.03	0.23	0.29	0.29
Total FFC Energy	0.09	0.48	0.70	0.96

OMB Circular A–4 [167] 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 NOPR, DOE undertook a sensitivity analysis using 9 years, rather than 30 years, of equipment 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.[168] The review timeframe established in EPCA is generally not synchronized with the equipment lifetime, equipment manufacturing cycles, or other factors specific to commercial water heaters. Thus, such results are presented for informational purposes only and are not indicative of any change in DOE's analytical methodology. The NES sensitivity analysis results based on a 9-year analytical period are presented in Table V.32 of this NOPR. The impacts are counted over the lifetime of commercial water heaters purchased in 2026–2034.

TABLE V.32—CUMULATIVE NATIONAL ENERGY SAVINGS FOR CWH EQUIPMENT; 9 YEARS OF SHIPMENTS
[2026–2034]

	Trial standard level (*quads*)			
	1	2	3	4
Primary Energy:				
Commercial gas-fired storage and storage-type instantaneous	0.01	0.06	0.10	0.16
Residential-duty gas-fired storage	0.00	0.01	0.02	0.03
Instantaneous gas-fired tankless	0.00	0.00	0.00	0.00
Instantaneous circulating water heaters and hot water supply boilers	0.01	0.05	0.06	0.06
Total Primary Energy	0.03	0.13	0.18	0.25
FFC Energy:				
Commercial gas-fired storage and storage-type instantaneous	0.01	0.07	0.11	0.17
Residential-duty gas-fired storage	0.01	0.01	0.02	0.03
Instantaneous gas-fired tankless	0.00	0.00	0.00	0.00
Instantaneous circulating water heaters and hot water supply boilers	0.01	0.06	0.07	0.07

[167] U.S. Office of Management and Budget. Circular A–4: Regulatory Analysis. September 17, 2003. Available at *www.whitehouse.gov/sites/whitehouse.gov/files/omb/circulars/A4/a-4.pdf* (last accessed July 7, 2021).

[168] 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.32—CUMULATIVE NATIONAL ENERGY SAVINGS FOR CWH EQUIPMENT; 9 YEARS OF SHIPMENTS—Continued
[2026–2034]

	Trial standard level (*quads*)			
	1	2	3	4
Total FFC Energy	0.03	0.14	0.20	0.28

b. Net Present Value of Consumer Costs and Benefits

DOE estimated the cumulative NPV of the total costs and savings for consumers that would result from the TSLs considered for CWH equipment. In accordance with OMB's guidelines on regulatory analysis,[169] DOE calculated NPV using both a 7-percent and a 3-percent real discount rate. Table V.33 shows the consumer NPV results with impacts counted over the lifetime of equipment purchased in 2026–2055.

TABLE V.33—CUMULATIVE NET PRESENT VALUE OF CONSUMER BENEFITS FOR CWH EQUIPMENT; 30 YEARS OF SHIPMENTS
[2026–2055]

Discount rate	Trial standard level (billion 2020$)			
	1	2	3	4
3 percent:				
Commercial gas-fired storage and storage-type instantaneous	0.16	0.51	0.93	1.73
Residential duty gas-fired storage	0.05	0.05	0.11	0.21
Instantaneous gas-fired tankless	0.01	0.03	0.04	0.04
Instantaneous circulating water heaters and hot water supply boilers	0.07	0.27	0.41	0.41
Total NPV at 3 percent	0.29	0.86	1.49	2.40
7 percent:				
Commercial gas-fired storage and storage-type instantaneous	0.08	0.18	0.37	0.72
Residential duty gas-fired storage	0.02	0.01	0.03	0.07
Instantaneous gas-fired tankless	0.01	0.01	0.01	0.01
Instantaneous circulating water heaters and hot water supply boilers	0.02	0.03	0.07	0.07
Total NPV at 7 percent	0.12	0.22	0.48	0.88

The NPV results based on the aforementioned 9-year analytical period are presented in Table V.34 of this NOPR. The impacts are counted over the lifetime of equipment purchased in 2026–2034. As mentioned previously, such results are presented for informational purposes only and are not indicative of any change in DOE's analytical methodology or decision criteria.

TABLE V.34—CUMULATIVE NET PRESENT VALUE OF CONSUMER BENEFITS CWH EQUIPMENT; 9 YEARS OF SHIPMENTS
[2026–2034]

Discount rate	Trial standard level * (billion 2020$)			
	1	2	3	4
3 percent:				
Commercial gas-fired storage and storage-type instantaneous	0.07	0.09	0.26	0.56
Residential duty gas-fired storage	0.02	0.00	0.02	0.06
Instantaneous gas-fired tankless	0.00	0.00	0.01	0.01
Instantaneous circulating water heaters and hot water supply boilers	0.02	0.08	0.12	0.12
Total NPV at 3 percent	0.11	0.18	0.41	0.75
7 percent:				
Commercial gas-fired storage and storage-type instantaneous	0.04	0.03	0.13	0.31
Residential duty gas-fired storage	0.01	(0.00)	0.00	0.03
Instantaneous gas-fired tankless	0.00	0.00	0.00	0.00
Instantaneous circulating water heaters and hot water supply boilers	0.01	0.01	0.03	0.03

[169] U.S. Office of Management and Budget. Circular A–4: Regulatory Analysis. September 17, 2003. Available at *www.whitehouse.gov/sites/whitehouse.gov/files/omb/circulars/A4/a-4.pdf* (last accessed July 7, 2021).

TABLE V.34—CUMULATIVE NET PRESENT VALUE OF CONSUMER BENEFITS CWH EQUIPMENT; 9 YEARS OF SHIPMENTS—Continued

[2026–2034]

Discount rate	Trial standard level * (billion 2020$)			
	1	2	3	4
Total NPV at 7 percent	0.06	0.03	0.16	0.36

* A value in parentheses is a negative number.

c. Indirect Impacts on Employment

It is estimated that that amended energy conservation standards for CWH equipment 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 (2026–2030), 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.E.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 CWH equipment under consideration in this 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.E.1.e of this NOPR, 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 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 proposed rulemaking.

Energy conservation resulting from potential energy conservation standards for CWH equipment is expected to yield environmental benefits in the form of reduced emissions of certain air pollutants and greenhouse gases. Table V.35 provides DOE's estimate of cumulative emissions reductions expected to result from the TSLs considered in this proposed 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.36 presents cumulative FFC emissions by equipment class.

TABLE V.35—CUMULATIVE EMISSIONS REDUCTION FOR CWH EQUIPMENT SHIPPED IN 2026–2055

	Trial standard level			
	1	2	3	4
Power Sector Emissions				
CO_2 (*million metric tons*)	5	24	34	47
SO_2 (*thousand tons*)	(0.05)	(0.12)	(0.04)	0.06
NO_X (*thousand tons*)	4	21	30	41
Hg (*tons*)	(0.0005)	(0.0015)	(0.0014)	(0.0012)
CH_4 (*thousand tons*)	0.08	0.46	0.68	0.95
N_2O (*thousand tons*)	0.01	0.04	0.07	0.09
Upstream Emissions				
CO_2 (*million metric tons*)	0.56	2.91	4.20	5.73
SO_2 (*thousand tons*)	0.00	0.01	0.02	0.02
NO_X (*thousand tons*)	8.60	44.68	64.44	88.04

TABLE V.35—CUMULATIVE EMISSIONS REDUCTION FOR CWH EQUIPMENT SHIPPED IN 2026–2055—Continued

	Trial standard level			
	1	2	3	4
Hg (*tons*)	(0.00)	(0.00)	(0.00)	(0.00)
CH_4 (*thousand tons*)	62.79	325.91	469.86	641.78
N_2O (*thousand tons*)	0.00	0.00	0.01	0.01
Total FFC Emissions				
CO_2 (*million metric tons*)	5	26	38	52
SO_2 (*thousand tons*)	(0.05)	(0.11)	(0.02)	0.08
NO_X (*thousand tons*)	13	66	95	129
Hg (*tons*)	(0.0005)	(0.0016)	(0.0014)	(0.0012)
CH_4 (*thousand tons*)	63	326	471	643
N_2O (*thousand tons*)	0.01	0.05	0.07	0.10

Negative values refer to an increase in emissions.

TABLE V.36—CUMULATIVE FFC EMISSIONS REDUCTION FOR CWH EQUIPMENT SHIPPED IN 2026–2055, BY EQUIPMENT CLASS

Total FFC Emissions, Commercial Gas Storage and Storage-Type Instantaneous				
CO_2 (*million metric tons*)	2.4	11.5	18.0	30.6
SO_2 (*thousand tons*)	0.01	(0.10)	(0.05)	0.04
NO_X (*thousand tons*)	5.9	28.7	44.6	75.5
Hg (*tons*)	0.0000	(0.0010)	(0.0009)	(0.0008)
CH_4 (*thousand tons*)	29.3	142.5	221.6	375.4
N_2O (*thousand tons*)	0.005	0.020	0.034	0.060
Total FFC Emissions, Residential-Duty Gas-Fired Storage				
CO_2 (*million metric tons*)	0.9	1.8	3.7	5.2
SO_2 (*thousand tons*)	(0.01)	(0.03)	(0.02)	0.00
NO_X (*thousand tons*)	2.2	4.6	9.1	12.9
Hg (*tons*)	(0.0001)	(0.0003)	(0.0002)	(0.0002)
CH_4 (*thousand tons*)	11.0	23.1	45.5	63.9
N_2O (*thousand tons*)	0.00	0.00	0.01	0.01
Total FFC Emissions, Instantaneous Gas-Fired Tankless				
CO_2 (*million metric tons*)	0.3	0.8	1.0	1.0
SO_2 (*thousand tons*)	0.00	0.01	0.01	0.01
NO_X (*thousand tons*)	0.6	2.0	2.5	2.5
Hg (*tons*)	0.0000	0.0000	0.0000	0.0000
CH_4 (*thousand tons*)	3.1	9.7	12.5	12.5
N_2O (*thousand tons*)	0.00	0.00	0.00	0.00
Total FFC Emissions, Instantaneous Circulating Water Heaters and Hot Water Supply Boilers				
CO_2 (*million metric tons*)	1.5	12.3	15.6	15.6
SO_2 (*thousand tons*)	(0.06)	0.01	0.04	0.04
NO_X (*thousand tons*)	3.9	30.4	38.4	38.4
Hg (*tons*)	(0.0004)	(0.0003)	(0.0003)	(0.0003)
CH_4 (*thousand tons*)	19.5	150.8	190.6	190.6
N_2O (*thousand tons*)	0.00	0.02	0.03	0.03

Negative values refer to an increase in emissions.

As part of the analysis for this 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 CWH equipment. Section IV.L of this document discusses the SC–CO_2 values that DOE used. Table V.37 presents the value of CO_2 emissions reduction at each TSL.

TABLE V.37—PRESENT VALUE OF CO_2 EMISSIONS REDUCTION FOR CWH EQUIPMENT SHIPPED IN 2026–2055

TSL	SC–CO_2 case, discount rate and statistics (million 2020$)			
	5%	3%	2.5%	3%
	(Average)	(Average)	(Average)	(95th percentile)
1	42.72	188.75	297.10	572.26
2	216.02	965.28	1,524.73	2,925.16
3	315.92	1,406.42	2,218.97	4,262.76
4	441.12	1,950.37	3,070.51	5,913.66

As discussed in section IV.L.1 of this document, DOE estimated monetary benefits likely to result from the reduced emissions of methane and N_2O that DOE estimated for each of the considered TSLs for CWH equipment. Table V.38 presents the value of the CH_4 emissions reduction at each TSL, and Table V.39 presents the value of the N_2O emissions reduction at each TSL.

TABLE V.38—PRESENT VALUE OF METHANE EMISSIONS REDUCTION FOR CWH EQUIPMENT SHIPPED IN 2026–2055

TSL	SC–CH_4 case			
	Discount rate and statistics (million 2020$)			
	5%	3%	2.5%	3%
	Average	Average	Average	95th percentile
1	24.18	74.88	105.36	198.50
2	122.53	385.00	543.61	1,022.35
3	178.13	556.88	785.40	1,477.79
4	247.24	765.51	1,077.28	2,028.76

TABLE V.39—PRESENT VALUE OF NITROUS OXIDE EMISSIONS REDUCTION FOR CWH EQUIPMENT SHIPPED IN 2026–2055

TSL	SC–N_2O case			
	Discount rate and statistics (million 2020$)			
	5%	3%	2.5%	3%
	Average	Average	Average	95th percentile
1	0.03	0.12	0.18	0.31
2	0.15	0.62	0.99	1.67
3	0.23	0.95	1.49	2.54
4	0.32	1.34	2.11	3.59

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 economic benefits associated with NO_X and SO_2 emissions reductions anticipated to result from the considered TSLs for CWH equipment. The dollar-per-ton values that DOE used are discussed in section IV.L of this document. Table V.40 presents the present value for NO_X emissions reduction for each TSL calculated using 7-percent and 3-percent discount rates, and Table V.41 presents similar results for SO_2 emissions reductions. The results in these tables reflect application of the low dollar-per-ton values, which DOE used to be conservative. Results that reflect high dollar-per-ton values are presented in chapter 14 of the NOPR TSD.

TABLE V.40—PRESENT VALUE OF NO_X EMISSIONS REDUCTION FOR CWH EQUIPMENT SHIPPED IN 2026–2055

TSL	Million 2020$	
	3% discount rate	7% discount rate
1	356	137
2	1,800	671
3	2,627	990
4	3,663	1,406

TABLE V.41—PRESENT VALUE OF SO_2 EMISSIONS REDUCTION FOR CWH EQUIPMENT SHIPPED IN 2026–2055

TSL	Million 2020$	
	3% discount rate	7% discount rate
1	(2.84)	(0.89)
2	(10.36)	(4.17)
3	(7.23)	(2.85)
4	(3.17)	(1.11)

The benefits of reduced CO_2, CH_4, and N_2O emissions are collectively referred to as climate benefits. The benefits of reduced SO_2 and NO_X emissions are collectively referred to as health benefits. For the time series of estimated monetary values of reduced emissions, see chapter 14 of the NOPR TSD.

7. Other Factors

The Secretary of Energy, in determining whether a standard is economically justified, may consider any other factors that the Secretary deems to be relevant. (42 U.S.C. 6295(o)(2)(B)(i)(VII)) No other factors were considered in this analysis.

8. Summary of National Economic Impacts

Table V.42 presents the NPV values that result from adding the estimates of the potential climate and health benefits resulting from reduced GHG, SO_2, and NO_X emissions to the NPV of consumer benefits for each TSL considered in this rulemaking. The consumer benefits are domestic U.S. monetary savings that occur as a result of purchasing the covered commercial water heaters, and are measured for the lifetime of products shipped in 2026–2055. The climate benefits associated with reduced GHG emissions resulting from the adopted standards are global benefits, and are also calculated based on the lifetime of commercial water heaters shipped in 2026–2055. The climate benefits associated with four SC–GHG estimates are shown. DOE does not have a single central SC–GHG point estimate and it emphasizes the importance and value of considering the benefits calculated using all four SC–GHG estimates.

TABLE V.42—NPV OF CONSUMER BENEFITS COMBINED WITH CLIMATE AND HEALTH BENEFITS FROM EMISSIONS REDUCTIONS

Category	TSL 1	TSL 2	TSL 3	TSL 4
3% discount rate for NPV of Consumer and Health Benefits (billion 2020$)				
5% d.r., Average SC–GHG case	0.71	2.99	4.61	6.75
3% d.r., Average SC–GHG case	0.91	4.00	6.08	8.78
2.5% d.r., Average SC–GHG case	1.05	4.72	7.12	10.21
3% d.r., 95th percentile SC–GHG case	1.42	6.60	9.85	14.01
7% discount rate for NPV of Consumer and Health Benefits (billion 2020$)				
5% d.r., Average SC–GHG case	0.33	1.23	1.96	2.97
3% d.r., Average SC–GHG case	0.52	2.24	3.43	5.00
2.5% d.r., Average SC–GHG case	0.66	2.96	4.47	6.43
3% d.r., 95th percentile SC–GHG case	1.03	4.84	7.21	10.23

The national operating cost savings are domestic U.S. monetary savings that occur as a result of purchasing CWH equipment, and are measured for the lifetime of products shipped in 2026–2055. The benefits associated with reduced GHG emissions achieved as a result of the adopted standards are also calculated based on the lifetime of CWH equipment shipped in 2026–2055.

C. Conclusion

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. 6313(a)(6)(A)(ii) and (C)(i)) In determining whether a standard is economically justified, the Secretary must determine whether the benefits of the standard exceed its burdens by, to the greatest extent practicable, considering the seven statutory factors discussed previously. (42 U.S.C. 6313(a)(6)(B)(ii)(I)–(VII) and 42 U.S.C. 6313(a)(6)(C)(i))

For this NOPR, DOE considered the impacts of amended standards for CWH equipment at each TSL, beginning with the maximum technologically feasible level, to determine whether that level was economically justified. Where the max-tech level was not justified, DOE then considered the next most efficient level and undertook the same evaluation until it reached the highest efficiency level that is both technologically feasible and economically justified and saves a significant amount of energy.

To aid the reader as DOE discusses the benefits and/or burdens of each TSL, tables in this section present a summary of the results of DOE's quantitative analysis for each TSL. In addition to the quantitative results presented in the tables, DOE also considers other burdens and benefits that affect economic justification. These include the impacts on identifiable subgroups of consumers who may be disproportionately affected by a national standard and impacts on employment.

DOE also notes that the economics literature provides a wide-ranging discussion of how consumers trade off upfront costs and energy savings in the absence of government intervention. Much of this literature attempts to explain why consumers appear to undervalue energy efficiency improvements. There is evidence that consumers undervalue future energy savings as a result of (1) a lack of information, (2) a lack of sufficient salience of the long-term or aggregate benefits, (3) a lack of sufficient savings to warrant delaying or altering purchases, (4) excessive focus on the short term, in the form of inconsistent weighting of future energy cost savings relative to available returns on other investments, (5) computational or other difficulties associated with the evaluation of relevant tradeoffs, and (6) a divergence in incentives (for example, between renters and owners, or builders and purchasers). Having less than perfect foresight and a high degree of uncertainty about the future, consumers may trade off these types of investments at a higher than expected rate between current consumption and uncertain future energy cost savings.

1. Benefits and Burdens of TSLs Considered for CWH Equipment Standards

Table V.43 and Table V.44 summarize the quantitative impacts estimated for each TSL for CWH equipment. The national impacts are measured over the lifetime of each class of CWH equipment purchased in the 30-year period that begins in the anticipated year of compliance with amended standards (2026–2055). The energy savings, emissions reductions, and value of emissions reductions refer to full-fuel-cycle results. DOE exercises its own judgment in presenting monetized climate benefits as recommended in 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 February 2021 Interim Estimates presented by the Interagency Working Group on the Social Cost of Greenhouse Gases. The efficiency levels contained in each TSL are described in section V.A of this document.

TABLE V.43—SUMMARY OF ANALYTICAL RESULTS FOR CWH EQUIPMENT TSLs: NATIONAL IMPACTS

Category	TSL 1	TSL 2	TSL 3	TSL 4
Cumulative FFC National Energy Savings (quads)				
Commercial gas-fired storage and storage-type instantaneous	0.04	0.21	0.33	0.56
Residential duty gas-fired storage	0.02	0.03	0.07	0.10
Instantaneous gas-fired tankless	0.00	0.01	0.02	0.02
Instantaneous circulating water heaters and hot water supply boilers	0.03	0.23	0.29	0.29
Total Quads	0.09	0.48	0.70	0.96
NPV of Consumer Costs and Benefits (billion 2020$)				
NPV at 3% discount rate:				
Commercial gas-fired storage and storage-type instantaneous	0.16	0.51	0.93	1.73
Residential duty gas-fired storage	0.05	0.05	0.11	0.21
Instantaneous gas-fired tankless	0.01	0.03	0.04	0.04
Instantaneous circulating water heaters and hot water supply boilers	0.07	0.27	0.41	0.41
Total NPV at 3% (billion 2020$)	0.29	0.86	1.49	2.40
NPV at 7% discount rate:				
Commercial gas-fired storage and storage-type instantaneous	0.08	0.18	0.37	0.72
Residential duty gas-fired storage	0.02	0.01	0.03	0.07
Instantaneous gas-fired tankless	0.01	0.01	0.01	0.01
Instantaneous circulating water heaters and hot water supply boilers	0.02	0.03	0.07	0.07
Total NPV at 7% (billion 2020$)	0.12	0.22	0.48	0.87
Cumulative FFC Emissions Reduction (Total FFC Emissions)				
CO_2 (million metric tons)	5	26	38	52
SO_2 (thousand tons)	(0.05)	(0.11)	(0.02)	0.08
NO_X (thousand tons)	13	66	95	129
Hg (tons)	(0.000)	(0.002)	(0.001)	(0.001)
CH_4 (thousand tons)	63	326	471	643
N_2O (thousand tons)	0.01	0.05	0.07	0.10
Present Value of Benefits and Costs (3% discount rate, billion 2020$)				
Consumer Operating Cost Savings	0.34	1.63	2.44	3.51
Climate Benefits *	0.26	1.35	1.96	2.72
Health Benefits **	0.35	1.79	2.62	3.66
Total Benefits †	0.96	4.77	7.03	9.89
Consumer Incremental Product Costs ‡	0.05	0.77	0.95	1.11
Consumer Net Benefits	0.29	0.86	1.49	2.40
Total Net Benefits	0.91	4.00	6.08	8.78
Present Value of Benefits and Costs (7% discount rate, billion 2020$)				
Consumer Operating Cost Savings	0.15	0.68	1.04	1.52
Climate Benefits *	0.26	1.35	1.96	2.72
Health Benefits **	0.14	0.67	0.99	1.40
Total Benefits †	0.55	2.70	3.99	5.64
Consumer Incremental Product Costs ‡	0.03	0.46	0.56	0.65
Consumer Net Benefits	0.12	0.22	0.48	0.87
Total Net Benefits	0.52	2.24	3.43	5.00

Note: This table presents the costs and benefits associated with commercial water heaters shipped in 2026–2055. These results include benefits to consumers which accrue after 2055 from the products shipped in 2026–2055.

* Climate benefits are calculated using four different estimates of the social cost of carbon (SC–CO_2), methane (SC–CH_4), and nitrous oxide (SC–N_2O) (model average at 2.5 percent, 3 percent, and 5 percent discount rates; 95th percentile at 3 percent discount rate), as shown in Table V.37 through Table V.39. Together these represent the global social cost of greenhouse gases (SC–GHG). For presentational purposes of this table, the climate benefits associated with the average SC–GHG at a 3 percent discount rate are shown, but the Department does not have a single central SC–GHG point estimate. See section IV.L of this document for more details.

** Health benefits are calculated using benefit-per-ton values for NO_X and SO_2. DOE is currently only monetizing $PM_{2.5}$ and (for NO_X) ozone precursor health benefits, but will continue to assess the ability to monetize other effects such as health benefits from reductions in direct $PM_{2.5}$ emissions. The health benefits are presented at real discount rates of 3 and 7 percent. See section IV.L of this document for more details.

† Total and net benefits include consumer, climate, and health benefits. For presentation purposes, total and net benefits for both the 3-percent and 7-percent cases are presented using the average SC–GHG with 3-percent discount rate, 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 SC–GHG estimates. See Table V.42 for net benefits using all four SC–GHG estimates. On March 16, 2022, the Fifth Circuit Court of Appeals (No. 22–30087) granted the federal government's emergency motion for stay pending appeal of the February 11, 2022, preliminary injunction issued in *Louisiana* v. *Biden,* No. 21–cv–1074–JDC–KK (W.D. La.). As a result of the Fifth Circuit's order, the preliminary injunction is no longer in effect, pending resolution of the federal government's appeal of that injunction or a further court order. Among other things, the preliminary injunction enjoined the defendants in that case from ''adopting, employing, treating as binding, or relying upon'' the interim estimates of the social cost of greenhouse gases—which were issued by the Interagency Working Group on the Social Cost of Greenhouse Gases on February 26, 2021—to monetize the benefits of reducing greenhouse gas emissions. In the absence of further intervening court orders, DOE will revert to its approach prior to the injunction and present monetized benefits where appropriate and permissible under law.

‡ Costs include incremental equipment costs as well as installation costs.

TABLE V.44—SUMMARY OF ANALYTICAL RESULTS FOR CWH EQUIPMENT TSLS: MANUFACTURER AND CONSUMER IMPACTS

Category	TSL 1 *	TSL 2 *	TSL 3 *	TSL 4 *
Manufacturer Impacts: INPV (million 2020$)				
Commercial gas-fired storage and storage-type instantaneous (No-new-standards case INPV=134.6)	133.5–133.9	127.8–130.4	121.1–125.1	70.1–76.6
Residential-duty gas-fired storage (No-new-standards case INPV=10.1)	9.8–10.1	9.2–9.9	8.4–10.6	5.7–8.1
Instantaneous gas-fired tankless (No-new-standards case INPV=7.1)	6.8–6.8	6.1–6.2	6.1–6.3	6.1–6.3
Instantaneous circulating water heaters and hot water supply boilers (No-new-standards case INPV = 31.3)	31.1–31.3	28.0–33.2	24.0–30.2	24.0–30.2
Total INPV ($) (No-new-standards case INPV = 183.1)	181.3–182.1	171.1–179.6	159.7–172.4	106.1–121.6
Manufacturer Impacts: Change in INPV (million 2020$)				
Total Change in INPV ($)	(1.85)–(1.03)	(12.03)–(3.50)	(23.39)–(10.75)	(77.00)–(61.53)
Manufacturer Impacts: Industry NPV (% Change)				
Commercial gas-fired storage and storage-type instantaneous	(0.8)–(0.5)	(5.1)–(3.1)	(10.0)–(7.0)	(47.9)–(43.1)
Residential-duty gas-fired storage	(3.0)–0.0	(8.7)–(2.4)	(16.5)–5.4	(44.0)–(19.7)
Instantaneous gas-fired tankless	(4.5)–(4.2)	(14.8)–(12.6)	(15.0)–(11.8)	(15.0)–(11.8)
Instantaneous circulating water heaters and hot water supply boilers	(0.5)–(0.1)	(10.5)–5.9	(23.2)–(3.4)	(23.2)–(3.4)
Total INPV (*% change*)	(1.0)–(0.6)	(6.6)–(1.9)	(12.8)–(5.9)	(42.0)–(33.6)
Consumer Average LCC Savings (2020$)				
Commercial Gas-Fired Storage and Storage-type Instantaneous Water Heaters	93	80	301	664
Residential-Duty Gas-Fired Storage	129	(20)	90	324
Gas-Fired Instantaneous Water Heaters and Hot Water Supply Boilers	113	400	599	599
—Instantaneous, Gas-Fired Tankless	42	40	63	63
—Instantaneous Water Heaters and Hot Water Supply Boilers	172	702	1,047	1,047
Shipment-Weighted Average *	101	120	322	605
Consumer Simple PBP (years)				
Commercial Gas-Fired Storage and Storage-type Instantaneous Water Heaters	1	7	5	4
Residential-Duty Gas-Fired Storage	3	9	9	7
Gas-Fired Instantaneous Water Heaters and Hot Water Supply Boilers	1	9	9	9
—Instantaneous, Gas-Fired Tankless	2	9	9	9
—Instantaneous Water Heaters and Hot Water Supply Boilers	1	9	9	9
Shipment-Weighted Average *	1	8	6	6

TABLE V.44—SUMMARY OF ANALYTICAL RESULTS FOR CWH EQUIPMENT TSLS: MANUFACTURER AND CONSUMER IMPACTS—Continued

Category	TSL 1 *	TSL 2 *	TSL 3 *	TSL 4 *
Percent of Consumers that Experience a Net Cost				
Commercial Gas-Fired Storage and Storage-type Instantaneous Water Heaters	1%	14%	12%	13%
Residential-Duty Gas-Fired Storage	2%	17%	26%	18%
Gas-Fired Instantaneous Water Heaters and Hot Water Supply Boilers	1%	10%	12%	12%
—Instantaneous, Gas-Fired Tankless	0%	9%	12%	12%
—Instantaneous Water Heaters and Hot Water Supply Boilers	2%	11%	13%	13%
Shipment-Weighted Average *	1%	14%	14%	13%

Parentheses indicate negative (−) values.
* Weighted by shares of each equipment class in total projected shipments in 2026.

DOE first considered TSL 4, which represents the max-tech efficiency levels. At this TSL, the Secretary has tentatively determined that the benefits are outweighed by the burdens, as discussed in detail in the following paragraphs.

TSL 4 would save an estimated 0.96 quads of energy, an amount DOE considers significant. Commercial gas-fired storage water heaters and storage-type instantaneous water heaters save an estimated 0.56 quads while Residential-Duty Gas-Fired Storage equipment save 0.10 quads of energy. Instantaneous gas-fired tankless water heaters are estimated to save 0.02 quads of energy, while instantaneous circulating water heaters and hot water supply boilers save an estimated 0.29 quads.

Under TSL 4, the NPV of consumer benefit would be $0.87 billion using a discount rate of 7 percent, and $2.40 billion using a discount rate of 3 percent. Much of the consumer benefit is provided by the commercial gas-fired storage water heaters and storage-type instantaneous water heaters totaling an estimated $0.72 billion using a 7 percent discount rate, and $1.73 billion using a 3 percent discount rate. The consumer benefit for residential-duty gas-fired storage water heaters is estimated to be $0.07 billion at a 7 percent discount rate and $0.21 billion at a 3 percent discount rate. The consumer benefit for instantaneous gas-fired tankless water heaters is estimated to be $0.01 billion at a 7 percent discount rate and $0.04 at a 3 percent discount rate, and the consumer benefit for instantaneous circulating water heaters and hot water supply boilers is estimated to be $0.07 billion at a 7 percent discount rate and $0.41 billion at a 3 percent discount rate.

The cumulative emissions reductions at TSL 4 are 52 Mt of CO_2, 0.08 thousand tons of SO_2, 129 thousand tons of NO_X, −0.0012 ton of Hg, 643 thousand tons of CH_4, and 0.10 thousand tons of N_2O. The estimated monetary value of the climate benefits from reduced GHG emissions (associated with the average SC–GHG at a 3-percent discount rate) at TSL 4 is $2.72 billion. The estimated monetary value of the health benefits from reduced NO_X and SO_2 emissions at TSL 4 is $3.66 billion using a 7-percent discount rate and $1.40 billion using a 3-percent discount rate.

Using a 7-percent discount rate for consumer benefits and costs, health benefits from reduced SO_2 and NO_X emissions, and the 3-percent discount rate case for climate benefits from reduced GHG emissions, the estimated total NPV at TSL 4 is $5.00 billion. Using a 3-percent discount rate for all benefits and costs, the estimated total NPV at TSL 4 is $8.76 billion. The estimated total NPV is provided for additional information, however DOE primarily relies upon the NPV of consumer benefits when determining whether a proposed standard level is economically justified.

At TSL 4, the average LCC impact is a savings of $664 for commercial gas-fired storage and storage-type instantaneous water heaters, $324 for residential-duty gas-fired storage water heaters, $63 for instantaneous gas-fired instantaneous water heaters, and $1,047 for instantaneous circulating water heaters and hot water supply boilers. The simple PBP is 4 years for commercial gas-fired storage water heaters, 7 years for residential-duty gas-fired storage water heaters, and 9 years for both the instantaneous gas-fired tankless water heaters and the instantaneous circulating water heaters and hot water supply boilers. The fraction of consumers experiencing a net LCC cost is 13 percent for commercial gas-fired storage water heaters and storage-type instantaneous water heaters, 18 percent for residential-duty gas-fired storage water heaters, 12 percent for instantaneous gas-fired tankless water heaters, and 13 percent for instantaneous circulating water heaters and hot water supply boilers.

At TSL 4, the projected change in manufacturer INPV ranges from a decrease of $77.0 million to a decrease of $61.5 million, which correspond to decreases of 42.0 percent and 33.6 percent, respectively. Conversion costs total $119.8 million.

Commercial gas-fired storage water heaters and storage type instantaneous equipment account for over 70 percent of unit shipments in the CWH industry. The projected change in manufacturer INPV for commercial gas-fired storage water heaters and storage type instantaneous equipment ranges from a decrease of $64.5 million to a decrease of $58.0 million, which correspond to decreases of 47.9 percent and 43.1 percent, respectively. The potentially large negative impacts on INPV are largely driven by industry conversion costs. In particular, there are substantial increases in product conversion costs at TSL 4 for commercial gas-fired storage water heaters and storage type instantaneous equipment manufacturers. There are several factors that lead to high product conversion costs for this equipment.

Currently, only two models of this equipment type from a single manufacturer can meet a 99 percent thermal efficiency standard, which represents less than 1 percent of the commercial gas-fired storage water heaters and storage type instantaneous equipment models currently offered on the market. The two models both have an input capacity of 300,000 Btu/h and share a similar design. The manufacturer of these models is a small business with less than 1 percent market share in the commercial gas storage water heater market. The company's ability to ramp-up production capacity at 99% thermal efficiency to serve a significantly larger portion of the market is unclear.

Nearly all existing models would need to be redesigned to meet a 99 percent thermal efficiency standard. Traditionally, manufacturers design their equipment platforms to support a range of models with varying input capacities and storage volumes, and the efficiency typically will vary slightly between models within a given platform. However, at TSL 4, manufacturers would not be able to maintain a platform approach to designing commercial gas-fired storage water heaters because the 99 percent thermal efficiency level represents the maximum achievable efficiency and there would be no allowance for slight variations in efficiency between individual models. At TSL 4, manufacturers would be required to individually redesign each model to optimize performance for one specific input capacity and storage volume combination. As a result, the industry's level of engineering effort and investment would grow significantly. In manufacturer interviews, some manufacturers raised concerns that they would not have sufficient engineering capacity to complete necessary redesigns within the 3-year conversion period. If manufacturers require more than 3 years to redesign all models, they would likely prioritize redesigns based on sales volume. There is risk that some models become unavailable, either temporarily or permanently.

Product conversion costs for commercial gas-fired storage water heaters and storage type instantaneous equipment are expected to reach $82.1 million over the three-year conversion period. These investment levels are six times greater than typical R&D spending on this equipment class over a three-year period. Compliance with DOE standards could limit other engineering and innovation efforts, such as developing heat pump water heaters for the commercial market, during the conversion period beyond compliance with amended energy conservation standards.

Residential-duty gas-fired storage water heaters account for approximately 14 percent of unit shipments in the CWH industry. At TSL 4, the projected change in INPV for residential-duty gas-fired storage water heaters ranges from a decrease of $4.5 million to a decrease of $2.0 million, which correspond to decreases of 44.0 percent and 19.7 percent, respectively. Conversion costs total $6.5 million.

The drivers of negative impacts on INPV for residential-duty gas-fired storage water heaters are largely identical to those identified for the commercial gas-fired storage water heaters. At TSL 4, there is only one manufacturer with a compliant model at this standard level. This represents less than 5 percent of models currently offered in the market. Product conversion costs are expected to reach $4.6 million over the conversion period as manufacturers have to optimize designs for each specific input capacity and storage volume combination.

Instantaneous gas-fired tankless water heaters account for 6 percent of unit shipments in the CWH industry. At TSL 4, the projected change in manufacturer INPV for instantaneous gas-fired tankless water heaters ranges from a decrease of $1.1 million to a decrease of $0.8 million, which correspond to decreases of 15.0 percent and 11.8 percent, respectively. Conversion costs total $1.8 million.

At TSL 4, approximately half of currently offered instantaneous gas-fired tankless water heaters models would meet TSL 4 today. While most manufacturers have some compliant models, manufacturers would likely develop cost-optimized models to compete in a market where energy efficiency provides less product differentiation. Product conversion cost are expected to reach $1.2 million.

Instantaneous circulating water heaters and hot water supply boilers account for over 7 percent of unit shipments in the CWH industry. At TSL 4, the projected change in manufacturer INPV for instantaneous circulating water heaters and hot water supply boilers ranges from a decrease of $7.3 million to a decrease of $1.1 million, which correspond to decreases of 23.2 percent and 3.4 percent, respectively. Conversion cost total $10.0 million.

At TSL 4, approximately 27 percent of instantaneous circulating water heaters and hot water supply boilers models would meet TSL 4 today. DOE notes that industry offers a large number of models to fit a wide range of installation requirements despite relatively low shipment volumes. Product conversion cost are expected to reach $8.1 million.

The Secretary tentatively concludes that at TSL 4 for CWH equipment, the benefits of energy savings, positive NPV of consumer benefits, emission reductions, and the estimated monetary value of the emissions reductions would be outweighed by the economic burden on some consumers, and the impacts on manufacturers, including the potentials for large conversion costs, reduced equipment availability, delayed technology innovation, and substantial reductions in INPV. As noted previously, only one small manufacturer currently produces commercial gas-fired storage water heaters at that level. Similarly, only one manufacturer currently produces residential-duty gas-fired water heaters at that level. In light of substantial conversion costs, it is unclear whether a sufficient quantity of other manufacturers would undertake the conversions necessary to offer a competitive range of products across the range of sizes and applications required for gas-fired storage water heaters. Consequently, the Secretary has 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 would save an estimated 0.70 quads of energy, an amount DOE also considers significant. Commercial gas-fired storage and storage-type instantaneous water heaters are estimated to save 0.33 quads while residential-duty gas-fired storage water heaters are estimated to save 0.07 quads of energy. Instantaneous gas-fired tankless water heaters are estimated to save 0.02 quads. Instantaneous circulating gas-fired water heaters and hot water supply boilers are estimated to save 0.29 quads of energy.

Under TSL 3, the NPV of consumer benefit would be $0.48 billion using a discount rate of 7 percent, and $1.49 billion using a discount rate of 3 percent. Benefits to consumers of commercial gas-fired storage and storage type instantaneous equipment are estimated to be $0.37 billion using a discount rate of 7 percent, and $0.93 billion using a discount rate of 3 percent. Consumer benefits for residential-duty gas-fired storage equipment are estimated to be $0.03 billion dollars at a 7 percent discount rate and $0.11 billion at a 3 percent discount rate. Benefits to consumers of instantaneous gas-fired tankless water heaters are estimated to be $0.01 billion at a 7 percent discount rate and $0.04 billion at a 3 percent discount rate, and consumer benefits for instantaneous circulating gas-fired water heaters and hot water supply boilers are estimated to be $0.07 billion at a 7 percent discount rate and 0.41 billion at a 3 percent discount rate.

The cumulative emissions reductions at TSL 3 are 38 Mt of CO_2, −0.02 thousand tons of SO_2, 95 thousand tons of NO_X, −0.0014 tons of Hg, 471 thousand tons of CH_4, and 0.07 thousand tons of N_2O. The estimated monetary value of the climate benefits from reduced GHG emissions reduction (associated with the average SC–GHG at a 3-percent discount rate) at TSL 3 is $1.96 billion. The estimated monetary value of the health benefits from reduced NO_X and SO_2 emissions at TSL 3 is $0.99 billion using a 7-percent discount rate and $2.62 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 $3.43 billion. Using a 3-percent discount rate for all benefits and costs, the estimated total NPV at TSL 3 is $6.08 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 $301 for commercial gas-fired storage and storage-type instantaneous water heaters, $90 for residential-duty gas-fired storage water heaters, $63 for instantaneous gas-fired tankless water heaters, and $1,047 for instantaneous circulating water heaters and hot water supply boilers. The simple PBP is 5 years for commercial gas-fired storage water heaters, 9 years for residential-duty gas-fired storage water heaters, and 9 years for both instantaneous gas-fired tankless water heaters and instantaneous circulating water heaters and hot water supply boilers. The fraction of consumers experiencing a net LCC cost is 12 percent for commercial gas-fired storage water heaters, 26 percent for residential-duty gas-fired storage water heaters, 12 percent for instantaneous gas-fired tankless water heaters, and 13 percent for instantaneous circulating water heaters and hot water supply boilers.

At TSL 3, the projected change in manufacturer INPV ranges from a decrease of $23.4 million to a decrease of $10.8 million, which correspond to decreases of 12.8 percent and 5.9 percent, respectively. At this level, industry free cash flow is estimated to drop by 95% in the year before the standards year. Conversion costs total $34.6 million.

At TSL 3, nearly all commercial gas-fired storage water heaters and storage type instantaneous equipment manufacturers have models at a range of input capacities and storage volumes that can meet 95 percent thermal efficiency. Approximately 34 percent of commercial gas-fired storage water heaters and storage type instantaneous models currently offered would meet TSL 3 today. Additionally, an amended standard at TSL 3 would allow manufacturers to design equipment platforms that support a range of models with varying input capacities and storage volumes, rather than having to optimize designs for each individual input capacity and storage volume combinations.

The change in INPV for commercial gas-fired storage water heaters and storage type instantaneous equipment ranges from a decrease of $13.5 million to a decrease of $9.5 million, which correspond to decreases of 10.0 percent and 7.0 percent, respectively. Product conversion costs are $11.6 million and capital conversion costs are $9.2 million, for a total of approximately $20.8 million. At this level, product conversion costs are typical of R&D spending over the conversion period.

At TSL 3, multiple residential-duty gas-fired storage water heater manufacturers offer models at a range of input capacities and storage volumes that can meet a UEF standard at this level today. Approximately 22 percent of current residential-duty gas-fired storage water heater models would meet TSL 3. An amended standard at TSL 3 would allow manufacturers to design equipment platforms that support a range of models with varying input capacities and storage volumes, rather than having to optimize designs for each individual input capacity and storage volume combination.

The projected change in INPV for residential-duty gas-fired storage water heaters ranges from a decrease of $1.7 million to an increase of $0.5 million, which correspond to a decrease of 16.5 percent and an increase of 5.4 percent, respectively. DOE expects conversion costs for this equipment class to reach $2.1 million.

At TSL 3, approximately half of instantaneous gas-fired tankless water heaters models would meet TSL 3 today. The projected change in manufacturer INPV for instantaneous gas-fired tankless water heaters ranges from a decrease of $1.1 million to a decrease of $0.8 million, which correspond to decreases of 15.0 percent and 11.8 percent, respectively. Conversion costs total $1.8 million.

At TSL 3, approximately 27 percent of instantaneous circulating water heaters and hot water supply boilers models would meet TSL 3 today. The projected change in manufacturer INPV for instantaneous circulating water heaters and hot water supply boilers ranges from a decrease of $7.3 million to a decrease of $1.1 million, which correspond to decreases of 23.2 percent and 3.4 percent, respectively. Conversion cost total $10.0 million.

After considering the analysis and weighing the benefits and burdens, the Secretary has tentatively concluded that a standard set at TSL 3 for CWH equipment would be economically justified. Notably, the benefits to consumers vastly outweigh the cost to manufacturers. At TSL 3, the NPV of consumer benefits, even measured at the more conservative discount rate of 7 percent, is over 2200 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 $1.96 billion in climate benefits (associated with the average SC–GHG at a 3-percent discount rate), and $0.30 billion (using a 3-percent discount rate) or $0.12 billion (using a 7-percent discount rate) in health benefits—the rationale becomes stronger still.

As stated, DOE conducts a ''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. The walk-down is not a comparative analysis, as a comparative analysis would result in the maximization of net benefits instead of energy savings that are technologically feasible and economically justified, which would be contrary to the statute. 86 FR 70892, 70908. Although DOE has not conducted a comparative analysis to select the proposed energy conservation standards, DOE notes at TSL 3 the conversion cost impacts for commercial gas storage and residential-duty gas-fired storage water heaters are less severe than TSL 4. For commercial gas storage water heaters, nearly all manufacturers have equipment that can meet TSL 3 across a range of input capacities and storage volumes. Similarly, for residential-duty commercial gas water heaters, multiple manufacturers currently produce equipment meeting TSL 3. The concerns of manufacturers being unable to offer a competitive range of equipment across the range of input capacities and storage volumes currently offered would be mitigated at TSL 3.

Although DOE considered proposed amended standard levels for CWH equipment by grouping the efficiency levels for each equipment category into TSLs, DOE evaluates all analyzed efficiency levels in its analysis. For commercial gas instantaneous water heaters (including tankless and circulating/hot water supply boilers) TSL 3 (*i.e.,* the proposed TSL) includes the max-tech efficiency levels, which is the maximum level determined to be technologically feasible. For commercial gas-fired storage water heaters and residential-duty gas-fired storage water heaters, TSL 3 includes efficiency levels that are one level below the max-tech efficiency level. As discussed previously, at the max-tech efficiency levels for gas-fired storage water heaters and residential-duty gas-fired storage water heaters there is a substantial risk of manufacturers being unable to offer a competitive range of equipment across the range of input capacities and storage volumes currently available. Setting standards at max-tech for these classes could limit other engineering and innovation efforts, such as developing heat pump water heaters for the commercial market, during the conversion period beyond compliance with amended energy conservation standards. The benefits of max-tech efficiency levels for commercial gas-fired storage water heaters and residential-duty gas-fired storage water heaters do not outweigh the negative impacts to consumers and manufacturers. Therefore, DOE has tentatively concluded that the max-tech efficiency levels are not justified.

Therefore, based on the previous considerations, DOE proposes to adopt the energy conservation standards for CWH equipment at TSL 3. The proposed amended energy conservation standards for CWH equipment, which are expressed as thermal efficiency and standby loss for commercial gas-fired storage and commercial gas-fired instantaneous water heaters and hot water supply boilers, and as UEF for residential-duty gas-storage water heaters, are shown in Table V.45 and Table V.46.

TABLE V.45—PROPOSED AMENDED ENERGY CONSERVATION STANDARDS FOR COMMERCIAL WATER HEATING EQUIPMENT EXCEPT FOR RESIDENTIAL-DUTY COMMERCIAL WATER HEATERS

Equipment	Size	Energy conservation standards *	
		Minimum thermal efficiency (%)	Maximum standby loss †
Gas-fired storage water heaters and storage-type instantaneous water heaters.	All	95	$0.86 \times [Q/800 + 110(V_r)^{1/2}]$ (Btu/h)
Electric instantaneous water heaters ‡	<10 gal	80	N/A
	≥10 gal	77	$2.30 + 67/V_m$ (%/h)
Gas-fired instantaneous water heaters and hot water supply boilers	<10 gal	96	N/A
	≥10 gal	96	$Q/800 + 110(V_r)^{1/2}$ (Btu/h)

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

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

‡ Energy conservation standards for electric instantaneous water heaters are included in EPCA. (42 U.S.C. 6313(a)(5)(D)–(E)) The compliance date for these energy conservation standards is January 1, 1994. In this NOPR, DOE proposes to codify these standards for electric instantaneous water heaters in its regulations at 10 CFR 431.110. Further discussion of standards for electric instantaneous water heaters is included in section III.B.4 of this NOPR.

TABLE V.46—PROPOSED AMENDED ENERGY CONSERVATION STANDARDS FOR RESIDENTIAL-DUTY GAS-FIRED COMMERCIAL WATER HEATERS

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

* Additionally, to be classified as a residential-duty water heater, a commercial water heater must meet the following conditions: (1) If requiring electricity, use single-phase external power supply; and (2) the water heater must not be designed to heat water at temperatures greater than 180 °F.

** Draw pattern is a classification of hot water use of a consumer water heater or residential-duty commercial water heater, based upon the first-hour rating. The draw pattern is determined using the *Uniform Test Method for Measuring the Energy Consumption of Water Heaters* in appendix E to subpart B of 10 CFR part 430.

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 2020$) of the benefits from operating products that meet the proposed standards (consisting primarily of operating cost savings from using less energy, minus increases in product purchase costs, and (2) the annualized monetary value of the benefits of GHG and NO_X emission reductions.

Table V.47 shows the annualized values for CWH equipment under TSL 3, expressed in 2020$. 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 a 3-percent discount rate case for climate benefits from reduced GHG emissions, the estimated cost of the proposed standards for CWH equipment is $59 million per year in increased equipment costs, while the estimated annual benefits are $110 million in reduced equipment operating costs, $113 million in climate benefits, and $104 million in health benefits. In this case, the net benefit amounts to $267 million per year.

Using a 3-percent discount rate for all benefits and costs, the estimated cost of the proposed standards for CWH equipment is $55 million per year in increased equipment costs, while the estimated annual benefits are $140 million in reduced operating costs, $113 million in climate benefits, and $150 million in health benefits. In this case, the net benefit would amount to $349 million per year.

TABLE V.47—ANNUALIZED BENEFITS AND COSTS OF PROPOSED ENERGY CONSERVATION STANDARDS FOR CWH EQUIPMENT

[TSL 3]

Category	Million 2020$/year		
	Primary estimate	Low-net-benefits estimate	High-net-benefits estimate
3% discount rate			
Consumer Operating Cost Savings	140.3	130.3	151.7
Climate Benefits *	112.8	107.2	117.8
Health Benefits **	150.4	143.5	170.0
Total Benefits †	404	381	439
Consumer Incremental Product Costs ‡	54.7	52.6	56.6
Net Benefits	349	328	383
7% discount rate			
Consumer Operating Cost Savings	109.6	103.4	116.7
Climate Benefits * (3% discount rate)	112.8	107.2	117.8
Health Benefits **	104.3	100.4	117.2
Total Benefits †	327	311	352
Consumer Incremental Product Costs ‡	59.2	57.5	60.9
Net Benefits	267	253	291

Note: This table presents the costs and benefits associated with consumer pool heaters shipped in 2026–2055. These results include benefits to consumers which accrue after 2055 from the products shipped in 2026–2055. Numbers may not add due to rounding.

* Climate benefits are calculated using four different estimates of the social cost of carbon (SC–CO_2), methane (SC–CH_4), and nitrous oxide (SC–N_2O) (model average at 2.5 percent, 3 percent, and 5 percent discount rates; 95th percentile at 3 percent discount rate). Together these represent the global social cost of greenhouse gases (SC–GHG). For presentational purposes of this table, the climate benefits associated with the average SC–GHG at a 3 percent discount rate are shown, but the Department does not have a single central SC–GHG point estimate, and it emphasizes the importance and value of considering the benefits calculated using all four SC–GHG estimates. See section IV.L of this document for more details.

** Health benefits are calculated using benefit-per-ton values for NO_X and SO_2. DOE is currently only monetizing $PM_{2.5}$ and (for NO_X) ozone precursor health benefits, but will continue to assess the ability to monetize other effects such as health benefits from reductions in direct $PM_{2.5}$ emissions. The health benefits are presented at real discount rates of 3 and 7 percent. See section IV.L of this document for more details.

† Total and net benefits include consumer, climate, and health benefits. For presentation purposes, total and net benefits for both the 3-percent and 7-percent cases are presented using the average SC–GHG with 3-percent discount rate, 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 SC–GHG estimates. On March 16, 2022, the Fifth Circuit Court of Appeals (No. 22–30087) granted the federal government's emergency motion for stay pending appeal of the February 11, 2022, preliminary injunction issued in *Louisiana* v. *Biden,* No. 21–cv–1074–JDC–KK (W.D. La.). As a result of the Fifth Circuit's order, the preliminary injunction is no longer in effect, pending resolution of the federal government's appeal of that injunction or a further court order. Among other things, the preliminary injunction enjoined the defendants in that case from ''adopting, employing, treating as binding, or relying upon'' the interim estimates of the social cost of greenhouse gases—which were issued by the Interagency Working Group on the Social Cost of Greenhouse Gases on February 26, 2021—to monetize the benefits of reducing greenhouse gas emissions. In the absence of further intervening court orders, DOE will revert to its approach prior to the injunction and present monetized benefits where appropriate and permissible under law.

‡ Costs include incremental equipment costs as well as installation costs.

VI. Procedural Issues and Regulatory Review

A. Review Under Executive Orders 12866 and 13563

Section 1(b)(1) of Executive Order (''E.O.'') 12866, ''Regulatory Planning and Review,'' 58 FR 51735 (Oct. 4, 1993), requires each agency to identify the problem that it intends to address, including, where applicable, the failures of private markets or public institutions that warrant new agency action, as well as to assess the significance of that problem. The problems that the proposed standards set forth in this NOPR are intended to address are as follows:

(1) Insufficient information and the high costs of gathering and analyzing relevant information leads some consumers to miss opportunities to make cost-effective investments in energy efficiency.

(2) In some cases, the benefits of more-efficient equipment are not realized due to misaligned incentives between purchasers and users. An example of such a case is when the equipment purchase decision is made by a building contractor or building owner who does not pay the energy costs.

(3) There are external benefits resulting from improved energy efficiency of appliances and equipment that are not captured by the users of such products. These benefits include externalities related to public health, environmental protection, and national energy security that are not reflected in energy prices, such as reduced emissions of air pollutants and greenhouse gases that impact human health and global warming. DOE attempts to quantify some of the

external benefits through use of social cost of carbon values.

The Administrator of the Office of Information and Regulatory Affairs (''OIRA'') in the OMB has determined that the proposed regulatory action is a significant regulatory action under section (3)(f) of Executive Order 12866. Accordingly, pursuant to section 6(a)(3)(B) of the Order, DOE has provided to OIRA:

(i) The text of the draft regulatory action, together with a reasonably detailed description of the need for the regulatory action and an explanation of how the regulatory action will meet that need; and

(ii) An assessment of the potential costs and benefits of the regulatory action, including an explanation of the manner in which the regulatory action is consistent with a statutory mandate. DOE has included these documents in the rulemaking record. A summary of the potential costs and benefits of the regulatory action is presented in Table VI.1.

TABLE VI.1—ANNUALIZED BENEFITS, COSTS, AND NET BENEFITS OF PROPOSED STANDARDS

Category	Million 2020$/year	
	3% Discount rate	7% Discount rate
Consumer Operating Cost Savings	140.3	109.6
Climate Benefits *	112.8	112.8
Health Benefits **	17.3	12.3
Total Benefits †	270	235
Costs ‡	54.7	59.2
Net Benefits	216	175

Note: This table presents the costs and benefits associated with commercial water heaters shipped in 2026–2055. These results include benefits to consumers which accrue after 2055 from the products shipped in 2026–2055.

* Climate benefits are calculated using four different estimates of the global SC–CO_2, SC–CH_4, and SC–N_2O (see section IV.L of this proposed rule). Together these represent the global social cost of greenhouse gases (SC–GHG). For presentational purposes of this table, the climate benefits associated with the average SC–GHG at a 3 percent discount rate are shown, but the Department does not have a single central SC–GHG point estimate, and it emphasizes the importance and value of considering the benefits calculated using all four SC–GHG estimates.

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

† Total benefits include consumer, climate, and health benefits. 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. On March 16, 2022, the Fifth Circuit Court of Appeals (No. 22–30087) granted the federal government's emergency motion for stay pending appeal of the February 11, 2022, preliminary injunction issued in *Louisiana* v. *Biden,* No. 21–cv–1074–JDC–KK (W.D. La.). As a result of the Fifth Circuit's order, the preliminary injunction is no longer in effect, pending resolution of the federal government's appeal of that injunction or a further court order. Among other things, the preliminary injunction enjoined the defendants in that case from ''adopting, employing, treating as binding, or relying upon'' the interim estimates of the social cost of greenhouse gases—which were issued by the Interagency Working Group on the Social Cost of Greenhouse Gases on February 26, 2021—to monetize the benefits of reducing greenhouse gas emissions. In the absence of further intervening court orders, DOE will revert to its approach prior to the injunction and present monetized benefits where appropriate and permissible under law.

‡ Costs include incremental equipment costs as well as installation costs.

In addition, the Administrator of OIRA has determined that the proposed regulatory action is an ''economically'' significant regulatory action under section (3)(f)(1) of E.O. 12866. Accordingly, pursuant to section 6(a)(3)(C) of the Order, DOE has provided to OIRA an assessment, including the underlying analysis, of benefits and costs anticipated from the 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 can be found in the technical support document for this proposed rulemaking.

DOE has also reviewed this regulation pursuant to E.O. 13563, issued on January 18, 2011. 76 FR 3281 (Jan. 21, 2011). E.O. 13563 is supplemental to and explicitly reaffirms the principles, structures, and definitions governing regulatory review established in E.O. 12866. To the extent permitted by law, agencies are required by E.O. 13563 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, OIRA 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 NOPR is consistent with these principles, including the requirement that, to the extent permitted by law, benefits justify costs and that net benefits are maximized.

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 Executive Order 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*). The following sections detail DOE's IRFA for this energy conversation standards proposed rulemaking.

1. Description of Reasons Why Action Is Being Considered

DOE is proposing to amend energy conservation standards for CWH equipment. Pursuant to EPCA, DOE is to consider amending the energy efficiency standards for certain types of commercial and industrial equipment, including the equipment at issue in this document, whenever the American Society of Heating, Refrigerating, and Air-Conditioning Engineers (''ASHRAE'') amends the standard levels or design requirements prescribed in ASHRAE Standard 90.1, ''Energy Standard for Buildings Except Low-Rise Residential Buildings,'' (''ASHRAE Standard 90.1''), and at a minimum, every six 6 years. DOE must adopt more stringent efficiency standards, unless DOE determines, supported by clear and convincing evidence, that adoption of a more stringent level would produce significant additional conservation of energy would be technologically feasible and economically justified. (42 U.S.C. 6313(a)(6)(A)–(C))

2. Objectives of, and Legal Basis for, Rule

Under EPCA, DOE must review energy efficiency standards for CWH equipment every six years and either: (1) Issue a notice of determination that the standards do not need to be amended as adoption of a more stringent level is not supported by clear and convincing evidence; or (2) issue a notice of proposed rulemaking including new proposed standards based on certain criteria and procedures in subparagraph (B) of 42 U.S.C. 6313(a)(6). (42 U.S.C. 6313(a)(6)(C))

Under EPCA, DOE's energy conservation program consists essentially of four parts: (1) Testing, (2) labeling, (3) Federal energy conservation standards, and (4) certification and enforcement procedures. For covered equipment, relevant provisions of the Act include definitions (42 U.S.C. 6311), energy conservation standards (42 U.S.C. 6313), test procedures (42 U.S.C. 6314), labeling provisions (42 U.S.C. 6315), and the authority to require information and reports from manufacturers (42 U.S.C. 6316). DOE requires the manufacturer of any covered product or covered equipment to establish, maintain, and retain the records of certification reports, of the underlying test data for all certification testing, and of any other testing conducted to satisfy the requirements of 10 CFR part 429, 10 CFR part 430, and/or 10 CFR part 431. Certification reports provide DOE and consumers with comprehensive, up-to date efficiency information and support effective enforcement.

3. Description on Estimated Number of Small Entities Regulated

For manufacturers of CWH equipment, the Small Business Administration (''SBA'') has set a size threshold, which defines those entities classified as ''small businesses'' for the purposes of the statute. DOE used the SBA's small business size standards to determine whether any small entities would be subject to the requirements of the rule. *See* 13 CFR part 121. The equipment covered by this proposed rule are classified under North American Industry Classification System (''NAICS'') code 333318,[170] ''Other Commercial and Service Industry Machinery Manufacturing.'' In 13 CFR 121.201, the SBA sets a threshold of 1,000 employees or fewer for an entity to be considered as a small business for this category. DOE's analysis relied on publicly available databases to identify potential small businesses that manufacture equipment covered in this rulemaking. DOE utilized the California Energy Commission's Modernized Appliance Efficiency Database System (''MAEDbS''),[171] the DOE's Energy Star Database,[172] and the DOE's Certification Compliance Database (''CCD'') [173] in identifying manufacturers. For the purpose of this NOPR, two analyses are being performed regarding impacts to small businesses: (1) Impact of the amended standards and (2) impact of the codification of requirements for electric instantaneous water heater manufacturers.

Regarding manufacturers impacted by the amended standards, DOE identified fifteen original equipment manufacturers (''OEM''). DOE screened out companies that do not meet the definition of a ''small business'' or are foreign-owned and operated. DOE used subscription-based business information tools to determine headcount and revenue of the small businesses. Of these fourteen OEMs, DOE identified three companies that are small, domestic OEMs.

Regarding models impacted by the codification of requirements for electric instantaneous water heaters, DOE's research identified 9 OEMs of commercial electric instantaneous water heaters being sold in the U.S. market. Of these nine companies, DOE has identified three as domestic, small businesses. The small businesses do not currently certify any other CWH equipment to DOE's CCMS.

Issue 12: DOE seeks comment on the number of small manufacturers producing covered CWH equipment.

4. Description and Estimate of Compliance Requirements

This NOPR proposes to adopt amended standards for gas-fired storage water heaters, gas-fired instantaneous water heaters and hot water supply boilers, and residential-duty gas-fired storage water heaters. Additionally, this NOPR seeks to codify energy conservation standards for electric instantaneous water heaters from EPCA into the CFR.

To determine the impact on the small OEMs, product conversion costs and capital conversion costs were estimated. Product conversion costs are investments in research, development, testing, marketing, and other non-capitalized costs necessary to make product designs comply with amended energy conservation standards. Capital conversion costs are one-time investments in plant, property, and

[170] The business size standards are listed by NAICS code and industry description and are available at *www.sba.gov/document/support--table-size-standards* (Last accessed July 26th, 2021).

[171] MAEDbS can be accessed at *www.cacertappliances.energy.ca.gov/Pages/Search/AdvancedSearch.aspx* (Last accessed July 15th, 2021).

[172] Energy Star certified product can be found in the Energy Star database accessed at *www.energystar.gov/productfinder/product/certified-commercial-water-heaters/results* (Last accessed July 15th, 2021).

[173] Certified equipment in the CCD are listed by product class and can be accessed at *www.regulations.doe.gov/certification-data/#q=Product_Group_s%3A** (Last accessed July 15th, 2021).

equipment made in response to new and/or amended standards.

In reviewing all commercially available models in DOE's Compliance Certification Database, the three small manufacturers account for approximately 4 percent of industry model offerings. Of the three small manufacturers, the first manufacturer exclusively manufactures gas-fired instantaneous tankless water heaters and will remain unimpacted by the proposed standards as 100 percent of models meet TSL 3 or higher. There are no anticipated capital conversion costs or production conversion costs required to meet proposed standards.

The second manufacturer exclusively manufacturers hot water supply boilers and 67 percent of its models are unimpacted by the proposed standards. DOE estimates that this manufacturer will incur approximately $16,700 in capital conversion costs and $15,650 in product conversion costs to meet proposed standards. The combined conversion costs represent less than one percent of the firm's anticipated revenue during the conversion period.

The third manufacturer primarily manufactures gas-fired storage water heaters and residential-duty gas fired storage water heaters. For this manufacturer, 53 percent of their models are unimpacted by the proposed standards. DOE estimates that this manufacturer will incur approximately $178,000 in capital conversion costs and $226,000 in product conversion costs to meet proposed standards. The combined conversion costs represent 2% of the firm's anticipated revenue during the conversion period.

In addition to proposing amended standards, this rulemaking, DOE is proposing to codify standards for electric instantaneous CWH equipment from EPCA into the CFR.

EPCA prescribes energy conservation standards for several classes of CWH equipment manufactured on or after January 1, 1994. (42 U.S.C. 6313(a)(5)) DOE codified these standards in its regulations for CWH equipment at 10 CFR 431.110. However, when codifying these standards from EPCA, DOE inadvertently omitted the standards put in place by EPCA for electric instantaneous water heaters. In the NOPR, DOE is proposing to codify these standards in its regulations at 10 CFR 431.110. This NOPR does not propose certification requirements for electric instantaneous water heaters. Thus, DOE estimates no additional paperwork costs on manufacturers of electric instantaneous water heater equipment as result of the NOPR.

Issue 13: DOE seeks comment on types of costs and magnitude of costs small manufacturers would incur as result of the amended standards proposed for CWH equipment and the codification of standards for commercial electric instantaneous water heaters.

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 being considered in this action.

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 a range of different efficiency levels and their respective impacts to both manufacturers and consumers. DOE first considered TSL 4. TSL 4 would save 0.96 quads of energy with a projected change in manufacturer INPV of −42.0 percent to −33.6 percent. TSL 4 has energy savings that are 37 percent higher than TSL 3.

DOE also considered TSL 2 and TSL 1. TSL 2 would save 0.48 quads of energy with the projected change in manufacturer INPV ranging from −6.6 percent to −1.9 percent. TSL 2 has energy savings that are 31 percent lower than TSL 3. TSL 1 would save 0.09 quads of energy with the projected change in manufacturer INPV ranging from −1.0 percent to −0.6 percent. TSL 1 has energy savings that are 87 percent lower than TSL 3.

Based on the presented discussion, DOE believes that TSL 3 would deliver the highest energy savings while mitigating the potential burdens placed on CWH equipment manufacturers, including small business manufacturers. Accordingly, DOE does not propose one of the other TSLs considered in the analysis, or the other policy alternatives 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. Manufacturers subject to DOE's energy efficiency standards may apply to DOE's Office of Hearings and Appeals for exception relief under certain circumstances. Manufacturers should refer to 10 CFR part 1003 for additional details.

C. Review Under the Paperwork Reduction Act

Manufacturers of CWH equipment must certify to DOE that their equipment complies with any applicable energy conservation standards. In certifying compliance, manufacturers must test their equipment according to the applicable DOE test procedures for CWH equipment, including any amendments adopted for those test procedures on the date that compliance is required. DOE has established regulations for the certification and recordkeeping requirements for all covered commercial consumer products and commercial equipment, including CWH equipment. (*See generally* 10 CFR part 429). The collection-of-information requirement for the certification and recordkeeping is subject to review and approval by OMB under the Paperwork Reduction Act (''PRA''). DOE's current reporting requirements have 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, certifying compliance, and completing and reviewing the collection of information.

Notwithstanding any other provision of the law, no person is required to respond to, nor shall any person be subject to a penalty for failure to comply with, a collection of information subject to the requirements of the PRA, unless that collection of information displays a currently valid OMB Control Number.

D. Review Under the National Environmental Policy Act of 1969

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 an interpretive rulemaking that that establishes energy conservation standards for consumer products or industrial equipment, none of the exceptions identified in CX 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. DOE will complete its NEPA review before issuing the final rule.

E. Review Under Executive Order 13132

Executive Order 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 that it will follow in the development of such regulations. 65 FR 13735. DOE has examined this NOPR 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 equipment that is the subject of this NOPR. States can petition DOE for exemption from such preemption to the extent, and based on criteria, set forth in EPCA (*See* 42 U.S.C. 6316(a) and (b); 42 U.S.C. 6297). Therefore, no further action is required by 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 Executive Order 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 Executive Order 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 NOPR meets the relevant standards of Executive Order 12988.

G. Review Under the Unfunded Mandates Reform Act of 1995

Title II of the Unfunded Mandates Reform Act of 1995 (UMRA) requires each Federal agency to assess the effects of Federal regulatory actions on State, local, and Tribal governments and the private sector. Public Law 104–4, sec. 201 (codified at 2 U.S.C. 1531). For a 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 ''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/gc/office-general-counsel.*

This NOPR does not contain a Federal intergovernmental mandate, nor is it expected to require expenditures of $100 million or more in any one year by the private sector. As a result, the analytical requirements of UMRA do not apply.

H. Review Under the Treasury and General Government Appropriations Act, 1999

Section 654 of the Treasury and General Government Appropriations Act, 1999 (Pub. L. 105–277) requires Federal agencies to issue a Family Policymaking Assessment for any rule that may affect family well-being. This NOPR 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 Executive Order 12630, ''Governmental Actions and Interference with Constitutionally Protected Property Rights,'' 53 FR 8859 (March 15, 1988), DOE has determined that this NOPR 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 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 CWH equipment, 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 on this proposed rule.

L. Information Quality

On December 16, 2004, OMB, in consultation with the Office of Science and Technology Policy (''OSTP''), issued its Final Information Quality Bulletin for Peer Review (''the Bulletin''). 70 FR 2664 (Jan. 14, 2005). The Bulletin establishes that certain scientific information shall be peer reviewed by qualified specialists before it is disseminated by the Federal Government, including influential scientific information related to agency regulatory actions. The purpose of the bulletin is to enhance the quality and credibility of the Government's scientific information. Under the Bulletin, the energy conservation standards rulemaking analyses are ''influential scientific information,'' which the Bulletin defines as ''scientific information the agency reasonably can determine will have or does have a clear and substantial impact on important public policies or private sector decisions.'' *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 report describing that peer review.[174] Generation of this report involved a rigorous, formal, and documented evaluation using objective criteria and qualified and independent reviewers to make a judgment as to the technical/scientific/business merit, the actual or anticipated results, and the productivity and management effectiveness of programs and/or projects. DOE has determined that the peer-reviewed analytical process continues to reflect current practice, and the Department followed that process for developing energy conservation standards in the case of the present SNOPR.

M. Materials Incorporated by Reference

In this NOPR, DOE proposes to incorporate by reference the following test standards:

(1) ASTM C177–13, ''Standard Test Method for Steady-State Heat Flux Measurements and Thermal Transmission Properties by Means of the Guarded-Hot-Plate Apparatus''; and

(2) ASTM C518–15, ''Standard Test Method for Steady-State Thermal Transmission Properties by Means of the Heat Flow Meter Apparatus.''

ASTM C177–13 is an industry-accepted test procedure for determining the R-value of a sample using a guarded-hot-plate apparatus. ASTM C177–13 is available on ASTM's website at *www.astm.org/c0177-13.html.*

ASTM C518–15 is an industry-accepted test procedure for determining the R-value of a sample using a heat flow meter apparatus. ASTM C518–15 is available on ASTM's website at *https://www.astm.org/c0518-15.html.*

VII. Public Participation

A. Participation in the Webinar

The time and date of the webinar are listed in the **DATES** section at the beginning of this document. If no participants register for the webinar then it will be cancelled. Webinar registration information, participant instructions, and information about the capabilities available to webinar participants will be published on DOE's website: *www1.eere.energy.gov/buildings/appliance_standards/standards.aspx?productid=36.* 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 an interest in the topics addressed in this proposed rule, or who is representative of a group or class of persons that has an interest in these issues, may request an opportunity to make an oral presentation at the webinar. Such persons may submit to *ApplianceStandardsQuestions@ee.doe.gov.* Persons who wish to speak should include with their request a computer file in WordPerfect, Microsoft Word, PDF, or text (ASCII) file format that briefly describes the nature of their interest in this rulemaking and the topics they wish to discuss. Such persons should also provide a daytime telephone number where they can be reached.

Persons requesting to speak should briefly describe the nature of their interest in this rulemaking and provide a telephone number for contact. DOE requests persons selected to make an oral presentation to submit an advance copy of their statements at least two weeks before the webinar. At its discretion, DOE may permit persons who cannot supply an advance copy of their statement to participate, if those persons have made advance alternative arrangements with the Building Technologies Office. As necessary, requests to give an oral presentation should ask for such alternative arrangements.

C. Conduct of the Webinar

DOE will designate a DOE official to preside at the webinar/public meeting 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/public meeting and until the end of the comment period, interested parties may submit further comments on the proceedings and any aspect of the rulemaking.

The webinar/public meeting will be conducted in an informal, conference style. DOE will present summaries of comments received before the webinar/public meeting, allow time for prepared general statements by participants, and encourage all interested parties to share their views on issues affecting this 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 rulemaking. The official conducting the webinar/public meeting will accept

[174] 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 August 25, 2021).

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/public meeting.

A transcript of the webinar/public meeting will be included in the docket, which can be viewed as described in the *Docket* section at the beginning of this proposed rule. 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 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* web page 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. 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. No 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, postal mail, or hand delivery/courier 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:

Issue 1: DOE requests comment on its assumption that the proposed test procedure amendments for residential-duty commercial water heaters are not expected to impact the efficiency ratings.

Issue 2: DOE requests comment and information on whether integrated heat pump water heaters are capable of meeting the same hot water loads as commercial electric storage water heaters that use electric resistance elements.

Issue 3: DOE requests comment on its proposed revisions to notes to the table of energy conservation standards in 10 CFR 431.110.

Issue 4: DOE seeks comments on the extraordinary venting cost adder. Specifically, DOE seeks data to estimate the fraction of consumers that might incur extraordinary costs, and the level of such extraordinary costs.

Issue 5: DOE seeks input on actual historical shipments for residential-duty gas-fired storage water heaters, gas-fired storage-type instantaneous water heaters, and for hot water supply boilers.

Issue 6: DOE seeks additional actual historical shipment information for commercial gas-fired instantaneous tankless water heaters covering the period between 2015 and 2020 to supplement the data provided in response to the withdrawn NOPR.

Issue 7: DOE seeks historical shipments data dividing shipments between condensing and non-condensing efficiencies, for all product types that comprise the subject of this rulemaking.

Issue 8: DOE seeks comment on the availability of systems that can be built by plumbing multiple individual water heaters together to achieve the same level of hot water delivery capacity.

Issue 9: DOE seeks input on the production facility and manufacturing process changes required as a result of potential amended standards for each equipment category. DOE also requests input on the costs associated with those facility and manufacturing changes.

Issue 10: DOE seeks comment on whether manufacturers expect manufacturing capacity constraints would limit equipment availability to customers in the timeframe of the amended standard compliance date (2026).

Issue 11: DOE requests information regarding the impact of cumulative regulatory burden on manufacturers of CWH equipment associated with multiple DOE standards or product-specific regulatory actions of other Federal agencies. Additionally, where industry-wide constraints exist as a result of other overlapping regulatory actions, DOE requests stakeholders help identify and quantify those constraints.

Issue 12: DOE seeks comment on the number of small manufacturers producing covered CWH equipment.

Issue 13: DOE seeks comment on types of costs and magnitude of costs small manufacturers would incur as result of the amended standards proposed for CWH equipment and the codification of standards for commercial electric instantaneous water heaters.

VIII. Approval of the Office of the Secretary

The Secretary of Energy has approved publication of this notice of proposed rulemaking and announcement of public meeting.

List of Subjects in 10 CFR Part 431

Administrative practice and procedure, Confidential business information, Incorporation by reference, Test procedures, Reporting and recordkeeping requirements.

Signing Authority

This document of the Department of Energy was signed on May 4, 2022, by Kelly J. Speakes-Backman, Principal Deputy Assistant Secretary for Energy Efficiency and Renewable Energy, pursuant to delegated authority from the Secretary of Energy. That document with the original signature and date is maintained by DOE. For administrative purposes only, and in compliance with requirements of the Office of the Federal Register, the undersigned DOE Federal Register Liaison Officer has been authorized to sign and submit the document in electronic format for publication, as an official document of the Department of Energy. This administrative process in no way alters the legal effect of this document upon publication in the **Federal Register**.

Signed in Washington, DC, on May 5, 2022.

Treena V. Garrett,

Federal Register Liaison Officer, U.S. Department of Energy.

For the reasons set forth in the preamble, DOE is proposing to amend part 431 of chapter II, subchapter D of title 10, Code of Federal Regulations, as set forth below:

PART 431—ENERGY EFFICIENCY PROGRAM FOR CERTAIN COMMERCIAL AND INDUSTRIAL EQUIPMENT

■ 1. The authority citation for part 431 continues to read as follows:

Authority: 42 U.S.C. 6291–6317; 28 U.S.C. 2461 note.

■ 2. Amend § 431.105 by:
■ a. Revising paragraph (a);
■ b. In paragraph (c)(1), removing ''§ 431.102'' and adding in its place, ''§§ 431.102; 431.110''; and
■ c. In paragraph (c)(2), removing ''§ 431.102t'' and adding in its place, ''§§ 431.102; 431.110''.

The revision reads as follows:

§ 431.105 Materials incorporated by reference.

(a) Certain material is incorporated by reference into this subpart with the approval of the Director of the Federal Register in accordance with 5 U.S.C. 552(a) and 1 CFR part 51. To enforce any edition other than that specified in this section, DOE must publish a document in the **Federal Register** and the material must be available to the public. All incorporation by reference (IBR) approved material is available for inspection at DOE, and at the National Archives and Records Administration (NARA). Contact DOE at: The U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy, Building Technologies Program, Sixth Floor, 950 L'Enfant Plaza SW, Washington, DC 20024, (202) 586–9127, *Buildings@ee.doe.gov, www.energy.gov/eere/buildings/building-technologies-office.* For information on the availability of this material at NARA, email: *fr.inspection@nara.gov,* or go to: *www.archives.gov/federal-register/cfr/ibr-locations.html.* The material may be obtained from the sources in the following paragraphs of this section.

* * * * *

■ 3. Revise § 431.110 to read as follows:

§ 431.110 Energy conservation standards and their effective dates.

(a) (1) Each commercial storage water heater, instantaneous water heater, and hot water supply boiler (excluding residential-duty commercial water heaters) must meet the applicable energy conservation standard level(s) as specified in table 1 to this paragraph. Any packaged boiler that provides service water that meets the definition of ''commercial packaged boiler'' in subpart E of this part, but does not meet the definition of ''hot water supply boiler'' in this subpart, must meet the requirements that apply to it under subpart E of this part.

(2) Water heaters and hot water supply boilers with a rated storage volume greater than 140 gallons described in table 1 to this paragraph need not meet the standby loss requirement if:

(i) The tank surface area is thermally insulated to R–12.5 or more, as determined using ASTM C177–13 or C518–15 (both incorporated by reference; see § 431.105)

(ii) A standing pilot light is not used; and

(iii) For gas-fired or oil-fired storage water heaters, they have a flue damper or fan-assisted combustion.

TABLE 1 TO § 431.110(a)—COMMERCIAL WATER HEATER ENERGY CONSERVATION STANDARDS

Equipment	Size	Energy conservation standards [a]			
		Minimum thermal efficiency (equipment manufactured on and after October 9, 2015)	Minimum thermal efficiency (equipment manufactured on and after [Compliance date of amended standards])	Maximum standby loss (equipment manufactured on and after October 29, 2003)	Maximum standby loss (equipment manufactured on and after [compliance date of amended standards])
Electric storage water heaters	All	N/A	N/A	$0.30 + 27/V_m$ (%/h)	$0.30 + 27/V_m$ (%/h)
Gas-fired storage water heaters and storage-type instantaneous water heaters.	All	80%	95%	$Q/800 + 110(V_r)^{1/2}$ (Btu/h)	$0.86 \times [Q/800 + 110(V_r)^{1/2}]$ (Btu/h)
Oil-fired storage water heaters	All	80%	80%	$Q/800 + 110(V_r)^{1/2}$ (Btu/h)	$Q/800 + 110(V_r)^{1/2}$ (Btu/h)
Electric instantaneous water heaters [b]	<10 gal	80%	80%	N/A	N/A
	≥10 gal	77%	77%	$2.30 + 67/V_m$ (%/h)	$2.30 + 67/V_m$ (%/h)

TABLE 1 TO § 431.110(a)—COMMERCIAL WATER HEATER ENERGY CONSERVATION STANDARDS—Continued

Equipment	Size	Energy conservation standards[a]			
		Minimum thermal efficiency (equipment manufactured on and after October 9, 2015)	Minimum thermal efficiency (equipment manufactured on and after [Compliance date of amended standards])	Maximum standby loss (equipment manufactured on and after October 29, 2003)	Maximum standby loss (equipment manufactured on and after [compliance date of amended standards])
Gas-fired instantaneous water heaters and hot water supply boilers.	<10 gal	80%	96%	N/A	N/A
	≥10 gal	80%	96%	$Q/800 + 110(V_r)^{1/2}$ (Btu/h)	$Q/800 + 110(V_r)^{1/2}$ (Btu/h)
Oil-fired instantaneous water heater and hot water supply boilers.	<10 gal	80%	80%	N/A	N/A
	≥10 gal	78%	78%	$Q/800 + 110(V_r)^{1/2}$ (Btu/h)	$Q/800 + 110(V_r)^{1/2}$ (Btu/h)

[a] V_m is the measured storage volume, and V_r is the rated storage volume, both in gallons. Q is the rated input in Btu/h, as determined pursuant to 10 CFR 429.44.n

[b] The compliance date for energy conservation standards for electric instantaneous water heaters is January 1, 1994.

(b) Each unfired hot water storage tank manufactured on and after October 29, 2003, must have a minimum thermal insulation of R–12.5.

(c) Each residential-duty commercial water heater must meet the applicable energy conservation standard level(s) in table 2 to this paragraph. Additionally, to be classified as a residential-duty commercial water heater, a commercial water heater must meet the following conditions:

(1) If the water heater requires electricity, it must use a single-phase external power supply; and

(2) The water heater must not be designed to heat water to temperatures greater than 180 °F

TABLE 2 TO § 431.110(C)—RESIDENTIAL-DUTY COMMERCIAL WATER HEATER ENERGY CONSERVATION STANDARDS

Equipment	Specifications	Draw pattern	Uniform energy factor[a]	
			Equipment manufactured before [compliance date of amended standards])	Equipment manufactured after [compliance date of amended standards]
Gas-fired storage	>75 kBtu/hr and ≤105 kBtu/hr and ≤120 gal	Very Small	$0.2674 - (0.0009 \times V_r)$	$0.5374 - (0.0009 \times V_r)$
		Low	$0.5362 - (0.0012 \times V_r)$	$0.8062 - (0.0012 \times V_r)$
		Medium	$0.6002 - (0.0011 \times V_r)$	$0.8702 - (0.0011 \times V_r)$
		High	$0.6597 - (0.0009 \times V_r)$	$0.9297 - (0.0009 \times V_r)$
Oil-fired storage	>105 kBtu/hr and ≤140 kBtu/hr and ≤120 gal	Very Small	$0.2932 - (0.0015 \times V_r)$	$0.2932 - (0.0015 \times V_r)$
		Low	$0.5596 - (0.0018 \times V_r)$	$0.5596 - (0.0018 \times V_r)$
		Medium	$0.6194 - (0.0016 \times V_r)$	$0.6194 - (0.0016 \times V_r)$
		High	$0.6470 - (0.0013 \times V_r)$	$0.6470 - (0.0013 \times V_r)$
Electric instantaneous	>12 kW and ≤58.6 kW and ≤2 gal	Very Small	0.80	0.80
		Low	0.80	0.80
		Medium	0.80	0.80
		High	0.80	0.80

[a] V_r is the rated storage volume (in gallons), as determined pursuant to 10 CFR 429.44.

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