FEDERAL REGISTER

Vol. 81 Tuesday,
No. 104 May 31, 2016

Part II

Department of Energy

10 CFR Parts 429 and 431
Energy Conservation Program: Energy Conservation Standards for Commercial Water Heating Equipment; Proposed Rule

DEPARTMENT OF ENERGY

10 CFR Parts 429 and 431

[Docket Number EERE–2014–BT–STD–0042]

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 of 1975 (EPCA), as amended, prescribes energy conservation standards for various consumer products and 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 also requires that every 6 years, the U.S. Department of Energy (DOE) must determine whether more-stringent, amended standards would be technologically feasible and economically justified, and would save a significant amount of energy. In this action, DOE has tentatively concluded that there is clear and convincing evidence to support more-stringent standards for several classes of the equipment that are the subject of this rulemaking. DOE did not consider more-stringent standards in this action for commercial oil-fired storage water heaters, whose standards were recently amended. Therefore, DOE proposes amended energy conservation standards for certain commercial water heating equipment, and also announces a public meeting to receive comment on these proposed standards and associated analyses and results.

DATES: *Meeting:* DOE will hold a public meeting on June 6, 2016, from 1:00 p.m. to 5:00 p.m., in Washington, DC. The meeting will also be broadcast as a webinar. See section VII, ''Public Participation,'' for webinar registration information, participant instructions, and information about the capabilities available to webinar participants.

Comments: DOE will accept comments, data, and information regarding this notice of proposed rulemaking (NOPR) before and after the public meeting, but no later than August 1, 2016. See section VII, ''Public Participation,'' for details.

Comments regarding the likely competitive impact of the proposed standards should be sent to the Department of Justice contact listed in the **ADDRESSES** section before June 30, 2016.

ADDRESSES: The public meeting will be held at the U.S. Department of Energy, Forrestal Building, Room 8E–089, 1000 Independence Avenue SW., Washington, DC 20585. To attend, please notify Ms. Brenda Edwards at (202) 586–2945. Please note that foreign nationals visiting DOE Headquarters are subject to advance security screening procedures. Any foreign national wishing to participate in the meeting should advise DOE as soon as possible by contacting Ms. Edwards to initiate the necessary procedures. Please also note that any person wishing to bring a laptop computer or tablet into the Forrestal Building will be required to obtain a property pass. Visitors should avoid bringing laptops, or allow an extra 45 minutes. Persons may also attend the public meeting via webinar. For more information, refer to section VII, ''Public Participation,'' near the end of this notice.

Instructions: Any comments submitted must identify the NOPR on Energy Conservation Standards for Commercial Water Heating Equipment, and provide docket number EERE–2014–BT–STD–0042 and/or regulatory information number (RIN) number 1904–AD34. Comments may be submitted using any of the following methods:

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

2. *Email: ComWaterHeating2014STD0042@ee.doe.gov*. Include the docket number and/or RIN in the subject line of the message. Submit electronic comments in WordPerfect, Microsoft Word, PDF, or ASCII file format, and avoid the use of special characters or any form of encryption.

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

4. *Hand Delivery/Courier:* Ms. Brenda Edwards, U.S. Department of Energy, Building Technologies Office, 950 L'Enfant Plaza SW., Suite 600, Washington, DC, 20024. Telephone: (202) 586–2945. If possible, please submit all items on a CD, in which case it is not necessary to include printed copies.

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 the Office of Energy Efficiency and Renewable Energy through the methods listed above and by email to *Chad_S._Whiteman@omb.eop.gov*.

EPCA requires the Attorney General to provide DOE a written determination of whether the proposed standard is likely to lessen competition. The U.S. Department of Justice Antitrust Division invites input from market participants and other interested persons with views on the likely competitive impact of the proposed standard. Interested persons may contact the Division at *energy.standards@usdoj.gov* before June 30, 2016. Please indicate in the ''Subject'' line of your email the title and Docket Number of this rulemaking notice.

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

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

A link to the docket Web page can be found at: *http://www.regulations.gov/#!docketDetail;D=EERE-2014-BT-STD-0042*. This Web page contains a link to the docket for this document on the *www.regulations.gov* site. The *www.regulations.gov* Web page contains simple instructions on how to access all documents, including public comments, in the docket. See section VII, ''Public Participation,'' for further information on how to submit comments through *www.regulations.gov*.

FOR FURTHER INFORMATION CONTACT:

Ms. Ashley Armstrong, 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: (202) 586–6590. Email: *Ashley.Armstrong@ee.doe.gov*.

Mr. Eric Stas, U.S. Department of Energy, Office of the General Counsel, GC–33, 1000 Independence Avenue SW., Washington, DC 20585–0121.

Telephone: (202) 586–9507. Email: *Eric.Stas@hq.doe.gov*.

For information on how to submit or review public comments and the docket, contact Ms. Brenda Edwards at (202) 586–2945 or by email: *Brenda.Edwards@ee.doe.gov*.

SUPPLEMENTARY INFORMATION:

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I. Synopsis of the Proposed Rule

Title III, Part C[1] of the Energy Policy and Conservation Act of 1975 (''EPCA'' or ''the Act''), Public Law 94–163 (42 U.S.C. 6311–6317, as codified), added by Public Law 95–619, Title IV, section 441(a), established the Energy Conservation Program for Certain Industrial Equipment,[2] which sets forth a variety of provisions designed to improve energy efficiency. These encompass several types of commercial heating, air-conditioning, and water heating equipment, including the classes of CWH equipment that are the subject of this rulemaking. (42 U.S.C. 6311(1)(K)) CWH equipment is also

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

[2] All references to EPCA in this document refer to the statute as amended through the Energy Efficiency Improvement Act of 2015 (EEIA 2015), Public Law 114–11 (April 30, 2015).

covered under the American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE) Standard 90.1 (ASHRAE Standard 90.1), ''Energy Standard for Buildings Except Low-Rise Residential Buildings.''

EPCA, as amended by the Energy Independence and Security Act of 2007 (EISA 2007), Public Law 110–140, requires DOE to conduct an evaluation of its standards for CWH equipment every 6 years and to publish either a notice of determination that such standards do not need to be amended or a notice of proposed rulemaking including proposed amended standards (42 U.S.C. 6313(a)(6)(C)(i)) Pursuant to these statutory requirements, DOE initiated this rulemaking to evaluate the energy conservation standards for covered CWH equipment and to determine whether new or amended standards are warranted.[3]

In addition, EPCA, as amended, also requires DOE to consider amending the existing Federal energy conservation standards for certain types of listed commercial and industrial equipment (generally, commercial water heaters, commercial packaged boilers, commercial air-conditioning and heating equipment, and packaged terminal air conditioners and heat pumps) each time ASHRAE Standard 90.1 is amended with respect to such equipment. (42 U.S.C. 6313(a)(6)(A)) For each type of equipment, EPCA directs that if ASHRAE Standard 90.1 is amended, DOE must publish in the **Federal Register** an analysis of the energy savings potential of amended energy conservation standards within 180 days of the amendment of ASHRAE Standard 90.1. (42 U.S.C. 6313(a)(6)(A)(i)) EPCA further directs that DOE must adopt amended energy conservation standards at the new efficiency level in ASHRAE Standard 90.1, unless clear and convincing evidence supports a determination that adoption of a more-stringent efficiency level as a national standard would produce significant additional energy savings and be technologically feasible and economically justified. (42 U.S.C. 6313(a)(6)(A)(ii)) If DOE decides to adopt as a national standard the efficiency levels specified in the amended ASHRAE Standard 90.1, DOE must establish such a standard not later than 18 months after publication of the amended industry standard. (42 U.S.C. 6313(a)(6)(A)(ii)(I)) If DOE determines that a more-stringent standard is appropriate under the statutory criteria, DOE must establish such more-stringent standard not later than 30 months after publication of the revised ASHRAE Standard 90.1. (42 U.S.C. 6313(a)(6)(B)(i))

On October 9, 2013, ASHRAE officially released ASHRAE Standard 90.1–2013, which, among other things, amended standard levels for commercial oil-fired storage water heaters greater than 105,000 Btu/h and less than 4,000 Btu/h/gal, a category of CWH equipment covered under EPCA, thereby triggering DOE's statutory obligation to promulgate an amended uniform national standard at those levels, unless DOE determines that there is clear and convincing evidence supporting the adoption of more-stringent energy conservation standards than the ASHRAE Standard 90.1 levels. Pursuant to 42 U.S.C. 6313(a)(6), DOE determined in a final rule published on July 17, 2015 (''July 2015 ASHRAE equipment final rule'') that a more-stringent thermal efficiency standard than the ASHRAE 90.1–2013 standard level for commercial oil-fired water heaters is not justified. 80 FR 42614. Therefore, DOE adopted the ASHRAE 90.1–2013 thermal efficiency standard for commercial oil-fired storage water heaters in the Code of Federal Regulations (CFR) at 10 CFR 431.110 with a compliance date of October 9, 2015. *Id.* In this NOPR, DOE proposes to maintain the standard levels for commercial oil-fired storage water heaters adopted in that final rule. For the other types of CWH equipment,[4] DOE was not triggered by ASHRAE action in adopting ASHRAE Standard 90.1–2013, so for those equipment classes, DOE proceeded under its 6-year-look-back authority. (42 U.S.C. 6313(a)(6)(C)(i))

Also relevant here, 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 residential water heaters and some CWH equipment. (42 U.S.C. 6295(e)(5)(B)) EPCA further requires the final rule must replace the current energy factor (for residential 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 the uniform energy factor (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 type that is subject to the new UEF metric and the corresponding UEF test procedures. 79 FR 40542, 40586–88 (July 11, 2014). DOE excludes from the UEF covered CWH equipment that is not a residential-duty commercial water heater. *Id.* Further details on the UEF metric and residential-duty commercial water heaters are discussed in section III.B of this document. For this NOPR, DOE analyzed and developed potential energy conservation standards for residential-duty commercial water heaters in terms of the current thermal efficiency and standby loss metrics because there are currently not sufficient test data for residential-duty commercial water heaters rated in UEF that DOE could use in its analyses for this NOPR. However, 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. DOE applied these conversion factors in converting the proposed standards for residential-duty commercial water heaters to UEF in this rulemaking. All other CWH equipment classes continue to have standards measured in terms of the thermal efficiency and standby loss metrics, with the exception of unfired hot water storage tanks, for which the energy

[3] As explained in further detail in section II.B.1, DOE most recently issued a final rule amending standards for commercial oil-fired storage water heaters on June 30, 2015, which was published in the **Federal Register** on July 17, 2015. 80 FR 42614. However, for all of the other water heating equipment that is the subject of this rulemaking, DOE last issued a final rule amending standards on January 4, 2001, which was published in the **Federal Register** on January 12, 2001. 66 FR 3336.

[4] Other types of CWH equipment include commercial electric storage water heaters, commercial gas-fired storage water heaters, residential-duty gas-fired storage water heaters, commercial gas-fired instantaneous water heaters and hot water supply boilers, commercial oil-fired instantaneous water heaters and hot water supply boilers, and commercial electric instantaneous water heaters. Commercial heat pump water heaters and unfired hot water storage tanks were not considered in this NOPR and energy conservations standards for these classes will be considered in a future rulemaking(s). Commercial electric instantaneous water heaters and commercial oil-fired instantaneous water heaters and hot water supply boilers were not analyzed for amended energy conservation standards in this NOPR because DOE determined amendment of standards for these classes would result in negligible energy savings. Section III.C includes further discussion on the scope of equipment classes analyzed in this NOPR.

conservation standard is a minimum R-value requirement for tank insulation.

Pursuant to EPCA, any new or amended energy conservation standard that DOE prescribes for CWH equipment shall be designed to achieve significant additional conservation of energy that DOE determines, supported by clear and convincing evidence, is both technologically feasible and economically justified. (42 U.S.C. 6313(a)(6)(A)(ii)(II) and (C)) In accordance with these and other statutory provisions discussed in this document, DOE has examined all of the CWH equipment classes (except for commercial oil-fired water heaters, which were addressed in a separate rulemaking, as noted above, and unfired hot water storage tanks, which will be examined in a separate rulemaking, as discussed in section III.C.4). Because DOE did not analyze amended energy conservations standards for unfired hot water storage tanks in this rule, DOE proposes to maintain the current R–12.5 minimum thermal insulation requirement for this class. DOE has tentatively concluded that more-stringent standards for commercial gas-fired storage water heaters, residential-duty commercial gas-fired storage water heaters, gas-fired instantaneous water heaters and hot water supply boilers, and electric storage water heaters are warranted. Accordingly, DOE is proposing amended energy conservation standards for these classes of CWH equipment. The proposed standards, if adopted, would apply to all equipment listed in Table I.1 and Table I.2 and manufactured in, or imported into, the United States on and after the compliance date of the standards (*i.e.,* 3 years after the publication date of the final rule). As shown in Table I.1 and Table I.2, the proposed standards are expressed in terms of: (1) Thermal efficiency, which describes the ratio of the heat energy (Btu/h) transferred to the water flowing through the water heater to the amount of energy (Btu/h) consumed by the water heater; (2) standby loss, which is the average hourly energy, expressed in Btu per hour, required to maintain the stored water temperature; or (3) uniform energy factor, which is a uniform efficiency descriptor that replaces thermal efficiency and standby loss for residential-duty commercial water heaters.

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

Equipment	Specifications **	Energy conservation standards *		Compliance date
		Minimum thermal efficiency (percent)	Maximum standby loss	
Electric storage water heaters	All	N/A	$0.84 \times [0.30 + 27/V_r]$ (*%/h*)	3 years after publication of final rule.
Gas-fired storage water heaters.	All ***	95	$0.63 \times [Q/800 + 110(V_r)^{1/2}]$ (*Btu/h*).	3 years after publication of final rule.
Oil-fired storage water heaters.	All ***	80	$Q/800 + 110(V_r)^{1/2}$ (*Btu/h*)	10/09/2015 †.
Electric instantaneous water heaters.	<10 gal ***	80	N/A	01/01/1994 †.
	≥10 gal	77	$2.30 + 67/V_r$ (*%/h*)	01/01/1994 †.
Gas-fired instantaneous water heaters and hot water supply boilers:				
Instantaneous water heaters (other than storage-type) and hot water supply boilers.	<10 gal	94	N/A	3 years after publication of final rule.
Instantaneous water heaters (other than storage-type) and hot water supply boilers.	≥10 gal	94	$Q/800 + 110(V_r)^{1/2}$ (*Btu/h*)	3 years after publication of final rule †††.
Storage-type instantaneous water heaters ††.	≥10 gal	95	$0.63 \times [Q/800 + 110(V_r)^{1/2}]$ (*Btu/h*).	3 years after publication of final rule.
Oil-fired instantaneous water heaters and hot water supply boilers:				
Instantaneous water heaters and hot water supply boilers.	<10 gal	80	N/A	10/09/2015 †
Instantaneous water heaters and hot water supply boilers.	≥10 gal	78	$Q/800 + 110(V_r)^{1/2}$ (*Btu/h*)	10/29/2003 †.

* V_r is the rated volume in gallons. Q is the fuel input rate in Btu/h.

** These specifications only distinguish between classes of CWH equipment. The different classifications for consumer water heaters and commercial water heating equipment are specified by the definitions codified at 10 CFR 430.2 and 10 CFR 431.102, respectively.

*** These standards only apply to commercial water heating equipment that does not meet the definition of "residential-duty commercial water heater." See Table I.2 for energy conservation standards proposed for residential-duty commercial water heaters.

† Amended standards for these equipment classes were not analyzed in this NOPR. Section III.C includes a discussion of the scope of equipment analyzed in this NOPR. Standards for electric instantaneous water heaters are included in EPCA. (42 U.S.C. 6313(a)(5)(D)–(E)) 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.C.5.

†† DOE proposes a new equipment class for storage-type instantaneous water heaters. This class of equipment is similar to storage water heaters in design, cost, and application. However, it has a ratio of input capacity to storage volume greater than or equal to 4,000 Btu/h per gallon of water stored; therefore, it is properly classified as an instantaneous water heater by EPCA's definition at 42 U.S.C. 6311(12)(B). Because of its similarities with storage water heaters, DOE grouped these two equipment classes together in its analyses for this NOPR. Storage-type instantaneous water heaters are further discussed in section IV.A.2.a.

††† Amended standby loss standards for instantaneous gas-fired water heaters and hot water supply boilers with greater than or equal to 10 gal water stored other than storage-type instantaneous water heaters were not analyzed in this NOPR. Section III.C.8 includes a discussion of the coverage of instantaneous water heaters and hot water supply boilers in this NOPR.

TABLE I.2—PROPOSED 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 and ≤180 °F.	Very Small	$0.4618 - (0.0010 \times Vr)$	3 years after publication of final rule.
		Low	$0.6626 - (0.0009 \times Vr)$	3 years after publication of final rule.
		Medium	$0.6996 - (0.0007 \times Vr)$	3 years after publication of final rule.
		High	$0.7311 - (0.0006 \times Vr)$	3 years after publication of final rule.
Oil-fired storage	>105 kBtu/h and ≤140 kBtu/h and ≤120 gal and ≤180 °F.	Very Small	$0.3206 - (0.0006 \times V_r)$	Conversion factor final rule publication date.††
		Low	$0.5577 - (0.0019 \times V_r)$	Conversion factor final rule publication date.††
		Medium	$0.6027 - (0.0019 \times V_r)$	Conversion factor final rule publication date.††
		High	$0.5446 - (0.0018 \times V_r)$	Conversion factor final rule publication date.††

* 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.

† Energy conservation standards for residential-duty commercial gas-fired storage water heaters at all four draw patterns were converted from the thermal efficiency and standby loss metrics to the new UEF metric using the conversion factors proposed by DOE in the April 2015 NOPR. 80 FR 20116, 20143 (April 14, 2015). In these equations, Vr is the rated storage volume.

†† Energy conservation standards in terms of UEF for residential-duty oil-fired storage water heaters will be established in a final rule for consumer water heaters and certain commercial water heaters, along with mathematical conversion factors for determining UEF. (See Docket No. EERE–2015–BT–TP–0007)

A. Benefits and Costs to Commercial Consumers

Table I.3 presents DOE's evaluation of the economic impacts of the proposed energy conservation standards on commercial consumers of CWH equipment, as measured by the average life-cycle cost (LCC) savings and the simple payback period (PBP).[5] The average LCC savings are positive for the standards DOE is proposing in this NOPR for all CWH equipment classes considered in this document. The estimated PBP for all proposed equipment classes are also less than the projected average lifetime of each equipment class, which varies from 10 to 25 years.

TABLE I.3—IMPACTS OF PROPOSED ENERGY CONSERVATION STANDARDS ON COMMERCIAL CONSUMERS OF COMMERCIAL WATER HEATING EQUIPMENT

Equipment class	Average LCC savings 2014$	Simple payback period years	Average lifetime years
Commercial gas-fired storage water heaters and storage-type instantaneous water heaters *	794	4.3	10
Residential-duty gas-fired storage water heaters	14	11.9	12
Gas-fired instantaneous water heaters and hot water supply boilers **	3,488	5.6	22.6
Tankless water heaters	1,119	Immediate †	17
Hot water supply boilers	4,528	6.4	25
Electric storage water heaters	47	6.5	12

* DOE proposes a new equipment class for storage-type instantaneous water heaters, which are similar to storage water heaters with a ratio of input capacity to storage volume greater than or equal to 4,000 Btu/h per gallon of water stored. Storage-type instantaneous water heaters are further discussed in section IV.A.2.a.

** Average LCC and PBP for the gas-fired instantaneous water heaters and hot water supply boilers class reflect use of shipment-weighted inputs to these calculated values to provide results for the class as a whole. Average lifetime of the gas-fired instantaneous water heaters and hot water supply boilers equipment class was a shipment-weighted average of the tankless water heater and hot water supply boiler lifetimes.

† Immediate payback can result from a decrease in installation cost that is greater than the incremental increase in equipment cost.

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

[5] The average LCC savings are measured relative to the no-new-standards-case efficiency distribution, which depicts the commercial water heating market in the compliance year in the absence of amended standard levels (see section IV.H.1 and chapter 8H of the TSD). The simple PBP, which is designed to compare specific efficiency levels for CWH equipment, is aggregate average payback measured relative to baseline CWH equipment (see section IV.F.3 and chapter 8 of the TSD).

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 (2015 to 2048). Using a real discount rate of 9.1 percent,[6] DOE estimates that the INPV for CWH equipment manufacturers is $176.2 million in 2014$ using DOE's current standards as a baseline. Under the proposed standards, DOE expects that the change in INPV will range from 5.0 percent to -13.3 percent, which is approximately equivalent to an increase of $8.8 million to a reduction of $23.4 million. Industry conversion costs are expected to total $29.8 million. Additional detail on DOE's calculations of INPV for CWH equipment manufacturers can be found in section V.B.2 of this NOPR and chapter 12 of the NOPR TSD. Based on DOE's interviews with CWH equipment manufacturers, DOE does not expect any plant closings or significant loss of employment to result from the proposed standards.

C. National Benefits and Costs[7]

DOE's analyses indicate that the proposed energy conservation standards for CWH equipment would save a significant additional amount of energy. The cumulative lifetime energy savings for CWH equipment shipped in the 30-year period[8] (which begins in the first full year of compliance with amended standards relative to the no-new-standards case without amended standards) amount to 1.8 quadrillion British thermal units (quads[9]) of cumulative full-fuel-cycle energy. This is a savings of 8 percent relative to the energy use of this equipment[10] in the case without amended standards. More details on energy savings can be found in chapter 10 of the NOPR TSD and sections IV.H, IV.L, and V.B.3 of this document.

The cumulative net present value (NPV) of total commercial consumer costs and savings of the proposed CWH equipment standards in 2014$ ranges from $2.26 billion (at a 7-percent discount rate) to $6.75 billion (at a 3-percent discount rate), respectively. This NPV expresses the estimated total value of future operating-cost savings minus the estimated increased equipment costs for CWH equipment shipped in 2019–2048 discounted back to the current year (2015). Chapter 10 of the NOPR TSD provides more details on the NPV analyses.

In addition, the proposed standards would have significant environmental benefits. The energy savings are estimated to result in cumulative emission reductions (over the same period as for energy savings) of 98 million metric tons (Mt)[11] of carbon dioxide (CO_2), 1,172 thousand tons of methane (CH_4), 0.2 thousand tons of nitrous oxide (N_2O), 1.6 thousand tons of sulfur dioxide (SO_2), 316 thousand tons of nitrogen oxides (NO_X), and 0.004 tons of mercury (Hg).[12] The cumulative reduction in CO_2 emissions through 2030 amounts to 15 Mt, which is equivalent to the emissions resulting from the annual electricity use of 2.1 million homes. More detailed emissions analysis results can be found in chapter 13 of the NOPR TSD.

The value of the CO_2 reductions is calculated using a range of values per metric ton of CO_2 (otherwise known as the Social Cost of Carbon, or SCC) developed by a recent Federal interagency process.[13] The derivation of the SCC values is discussed in section IV.L of this NOPR. Using discount rates appropriate for each set of SCC values, DOE estimates that the present monetary value of the CO_2 emissions reduction described above is between $0.64 and $9.11 billion, with a value of $2.99 billion using the central SCC case represented by $40.0 per metric ton in 2015.[14] Additionally, DOE estimates the present monetary value of the NO_X emissions reduction to be from $373 million at a 7-percent discount rate to $970 million at a 3-percent discount rate.[15] More detailed results can be found in chapter 14 of the NOPR TSD.

Table I.4 summarizes the national economic benefits and costs expected to result from this NOPR's proposed standards for CWH equipment.

TABLE I.4—SUMMARY OF NATIONAL ECONOMIC BENEFITS AND COSTS OF PROPOSED COMMERCIAL WATER HEATING EQUIPMENT ENERGY CONSERVATION STANDARDS (TSL 3) *

Category	Present value billion 2014$	Discount rate %
Benefits		
Commercial Consumer Operating Cost Savings	3.7	7
	9.3	3

[6] DOE estimated preliminary financial metrics, including the industry discount rate, based on data in Securities and Exchange Commission (SEC) filings and on industry-reviewed values published in prior water heating equipment final rules. DOE presented the preliminary financial metrics to manufacturers in manufacturer impact analysis (MIA) interviews. DOE adjusted those values based on feedback from manufacturers. The complete set of financial metrics and more detail about the methodology can be found in chapter 12 of the NOPR TSD.

[7] All monetary values in this section are expressed in 2014 dollars and, where appropriate, are discounted to 2015 unless explicitly stated otherwise. Energy savings in this section refer to the full-fuel-cycle savings (see section IV.H for discussion). National benefits of DOE's proposed standard levels are presented as compared to the current Federal standard levels as baseline.

[8] The 30-year analysis period is 2019–2048 for electric and gas-fired CWH equipment.

[9] A quad is equal to 10^{15} British thermal units (Btu).

[10] The no-new-standards-case assumptions are described in section IV.H.1 of this notice.

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

[12] DOE calculated emissions reductions relative to the no-new-standards case, which reflects key assumptions in the *Annual Energy Outlook 2015* (*AEO 2015*) Reference case. *AEO 2015* generally represents current legislation and environmental regulations for which implementing regulations were available as of October 31, 2014.

[13] *Technical Update of the Social Cost of Carbon for Regulatory Impact Analysis Under Executive Order 12866,* Interagency Working Group on Social Cost of Carbon, United States Government (May 2013; revised July 2015) (Available at: *https://www.whitehouse.gov/sites/default/files/omb/inforeg/scc-tsd-final-july-2015.pdf*).

[14] The values only include CO_2 emissions; CO_2 equivalent emissions from other greenhouse gases are not included.

[15] DOE estimated the monetized value of NO_X emissions reductions using benefit per ton estimates from the Regulatory Impact Analysis titled, ''Proposed Carbon Pollution Guidelines for Existing Power Plants and Emission Standards for Modified and Reconstructed Power Plants,'' published in June 2014 by EPA's Office of Air Quality Planning and Standards. (Available at *www3.epa.gov/ttnecas1/regdata/RIAs/111dproposalRIAfinal0602.pdf*.) See section IV.L.2 for further discussion. Note that the agency is presenting a national benefit-per-ton estimate for particulate matter emitted from the Electricity Generating Unit sector based on an estimate of premature mortality derived from the ACS study (Krewski et al. 2009). If the benefit-per-ton estimates were based on the Six Cities study (Lepuele et al. 2011), the values would be nearly two-and-a-half times larger. Because of the sensitivity of the benefit-per-ton estimate to the geographical considerations of sources and receptors of emissions, DOE intends to investigate refinements to the agency's current approach of one national estimate by assessing the regional approach taken by EPA's Regulatory Impact Analysis for the Clean Power Plan Final Rule. Note that DOE is currently investigating valuation of avoided SO_2 and Hg emissions.

TABLE I.4—SUMMARY OF NATIONAL ECONOMIC BENEFITS AND COSTS OF PROPOSED COMMERCIAL WATER HEATING EQUIPMENT ENERGY CONSERVATION STANDARDS (TSL 3) *—Continued

Category	Present value billion 2014$	Discount rate %
CO_2 Reduction (using mean SCC at 5% discount rate) **	0.6	5
CO_2 Reduction (using mean SCC at 3% discount rate) **	3.0	3
CO_2 Reduction (using mean SCC at 2.5% discount rate) **	4.8	2.5
CO_2 Reduction (using 95th percentile SCC at 3% discount rate) **.	9.1	3 (95th percentile)
NO_X Reduction †	0.4	7
	1.0	3
Total Benefits ††	7.1	7
	13.2	3
Costs		
Incremental Equipment Costs	1.5	7
	2.5	3
Total Net Benefits		
Including CO_2 and NO_X Reduction Monetized Value †	5.6	7
	10.7	3

* This table presents the costs and benefits associated with CWH equipment shipped in 2019–2048. These results include benefits to consumers that accrue after 2048 from the equipment purchased in 2019–2048. The incremental installed costs include incremental equipment cost as well as installation costs. The CO_2 reduction benefits are global benefits due to actions that occur nationally.

** The interagency group selected four sets of SCC values for use in regulatory analyses. Three sets of values are based on the average SCC from the integrated assessment models, at discount rates of 5, 3, and 2.5 percent. For example, for 2015 emissions, these values are $12.2/metric ton, $40.0/metric ton, and $62.3/metric ton, in 2014$, respectively. The fourth set ($117 per metric ton in 2014$ for 2015 emissions), which represents the 95th percentile of the SCC distribution calculated using SCC estimate across all three models at a 3-percent discount rate, is included to represent higher-than-expected impacts from temperature change further out in the tails of the SCC distribution. See section IV.L.1 for more details.

† The $/ton values used for NO_X are described in section IV.L. DOE estimated the monetized value of NO_X emissions reductions using benefit per ton estimates from the Regulatory Impact Analysis titled, "Proposed Carbon Pollution Guidelines for Existing Power Plants and Emission Standards for Modified and Reconstructed Power Plants," published in June 2014 by EPA's Office of Air Quality Planning and Standards. (Available at *www3.epa.gov/ttnecas1/regdata/RIAs/111dproposalRIAfinal0602.pdf.*) See section IV.L.2 for further discussion. Note that the agency is presenting a national benefit-per-ton estimate for particulate matter emitted from the Electric Generating Unit sector based on an estimate of premature mortality derived from the ACS study (Krewski et al. 2009). If the benefit-per-ton estimates were based on the Six Cities study (Lepuele et al. 2011), the values would be nearly two-and-a-half times larger. Because of the sensitivity of the benefit-per-ton estimate to the geographical considerations of sources and receptors of emissions, DOE intends to investigate refinements to the agency's current approach of one national estimate by assessing the regional approach taken by EPA's Regulatory Impact Analysis for the Clean Power Plan Final Rule.

†† Total benefits for both the 3-percent and 7-percent cases are presented using only the average SCC with 3-percent discount rate.

The benefits and costs of the proposed energy conservation standards, for CWH equipment shipped in 2019–2048, can also be expressed in terms of annualized values. The monetary values for the total annualized net benefits are the sum of: (1) The national economic value of the benefits in reduced operating costs, minus (2) the increase in equipment purchase prices and installation costs, plus (3) the value of the benefits of CO_2 and NO_X emission reductions, all annualized.[16]

The national operating savings are domestic private U.S. consumer monetary savings that occur as a result of purchasing this equipment. The national operating cost savings is measured for the lifetime of CWH equipment shipped in 2019–2048.

The CO_2 reduction is a benefit that accrues globally due to decreased domestic energy consumption that is expected to result from this rule. Because CO_2 emissions have a very long residence time in the atmosphere,[17] the SCC values in future years reflect future CO_2-emissions impacts that continue beyond 2100 through 2300.

Estimates of annualized benefits and costs of the proposed standards (over a 30-year period) are shown in Table I.5. The results under the primary estimate are as follows. Using a 7-percent discount rate for benefits and costs other than CO_2 reduction (for which DOE used a 3-percent discount rate along with the average SCC series that has a value of $40.0 per metric ton in 2015), the estimated cost of the CWH standards proposed in this document is $144 million per year in increased equipment costs, while the estimated benefits are $367 million per year in reduced equipment operating costs, $166 million per year from CO_2 reductions, and $37 million per year from reduced NO_X emissions. In this case, the annualized net benefit amounts to $427 million per year. Using a 3-percent discount rate for all benefits and costs and the average SCC series that has a value of $40.0 per metric ton in 2015, the estimated cost of the CWH standards proposed in this NOPR is $141 million per year in increased equipment costs, while the benefits are $517 million per year in reduced operating costs, $166 million from CO_2 reductions, and $54 million in reduced NO_X emissions. In this case, the

[16] To convert the time-series of costs and benefits into annualized values, DOE calculated a present value in 2015, the year used for discounting the NPV of total consumer costs and savings. For the benefits, DOE calculated a present value associated with each year's shipments in the year in which the shipments occur (*e.g.,* 2020 or 2030), and then discounted the present value from each year to 2015. 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.

[17] The atmospheric lifetime of CO_2 is estimated to be on the order of 30–95 years. Jacobson, MZ, "Correction to 'Control of fossil-fuel particulate black carbon and organic matter, possibly the most effective method of slowing global warming,' " *J. Geophys. Res.* 110. pp. D14105 (2005).

net benefit amounts to $597 million per year.

TABLE I.5—ANNUALIZED BENEFITS AND COSTS OF PROPOSED ENERGY CONSERVATION STANDARDS FOR COMMERCIAL WATER HEATING EQUIPMENT (TSL 3)*

	Discount rate %	Primary estimate	Low net benefits estimate	High net benefits estimate
			million 2014$/year	million 2014$/year
Benefits				
Commercial Consumer Operating Cost Savings.	7	367	336	411.
	3	517	465	588.
CO_2 Reduction (using mean SCC at 5% discount rate)*,**.	5	48	46	50.
CO_2 Reduction (using mean SCC at 3% discount rate)*,**.	3	166	159	176.
CO_2 Reduction (using mean SCC at 2.5% discount rate)*,**.	2.5	245	234	259.
CO_2 Reduction (using 95th percentile SCC at 3% discount rate)*,**.	3	508	485	536.
NO_X Reduction†	7	37	35	86.
	3	54	52	126.
Total Benefits††	7% plus CO_2 range	452 to 912	417 to 855	547 to 1,033.
	7	571	530	673.
	3% plus CO_2 range	619 to 1,079	563 to 1,001	765 to 1,251.
	3	737	676	890.
Costs				
Commercial Consumer Incremental Equipment Costs.	7	144	147	142.
	3	141	144	138.
Net Benefits/Costs				
Total††	7% plus CO_2 range	308 to 768	270 to 709	406 to 892.
	7	427	383	531.
	3% plus CO_2 range	478 to 938	419 to 857	627 to 1,113.
	3	597	532	752.

* This table presents the annualized costs and benefits associated with CWH equipment shipped in 2019–2048. These results include benefits to commercial consumers that accrue after 2048 from the equipment shipped in 2019–2048. The Primary, Low Benefits, and High Benefits Estimates for operating cost savings utilize projections of energy prices and building growth (leading to higher shipments) from the *AEO 2015* reference case, Low Estimate, and High Estimate, respectively. In addition, DOE used a constant price assumption as the default price projection; the cost to manufacture a given unit of higher efficiency neither increases nor decreases over time. The analysis of the price trends is described in section IV.F.2.a and appendix 10B of the NOPR TSD.

** The interagency group selected four sets of SCC values for use in regulatory analyses. Three sets of values are based on the average SCC from the integrated assessment models, at discount rates of 5, 3, and 2.5 percent. For example, for 2015 emissions, these values are $12.2/metric ton, $40.0/metric ton, and $62.3/metric ton, in 2014$, respectively. The fourth set ($117 per metric ton in 2014$ for 2015 emissions), which represents the 95th percentile of the SCC distribution calculated using SCC estimate across all three models at a 3-percent discount rate, is included to represent higher-than-expected impacts from temperature change further out in the tails of the SCC distribution. The SCC values are emission year specific. See section IV.L for more detail.

† The $/ton values used for NO_X are described in section IV.L. DOE estimated the monetized value of NO_X emissions reductions using benefit per ton estimates from the Regulatory Impact Analysis titled, "Proposed Carbon Pollution Guidelines for Existing Power Plants and Emission Standards for Modified and Reconstructed Power Plants," published in June 2014 by EPA's Office of Air Quality Planning and Standards. (Available at *www3.epa.gov/ttnecas1/regdata/RIAs/*111dproposalRIAfinal0602.pdf.) See section IV.L.2 for further discussion. Note that the agency is presenting a national benefit-per-ton estimate for particulate matter emitted from the Electric Generating Unit sector based on an estimate of premature mortality derived from the ACS study (Krewski et al. 2009). If the benefit-per-ton estimates were based on the Six Cities study (Lepuele et al. 2011), the values would be nearly two-and-a-half times larger. Because of the sensitivity of the benefit-per-ton estimate to the geographical considerations of sources and receptors of emissions, DOE intends to investigate refinements to the agency's current approach of one national estimate by assessing the regional approach taken by EPA's Regulatory Impact Analysis for the Clean Power Plan Final Rule.

†† Total benefits for both the 3-percent and 7-percent cases are presented using only the average SCC with a 3-percent discount rate. In the rows labeled "7% plus CO_2 range" and "3% plus CO_2 range," the operating cost and NO_X benefits are calculated using the labeled discount rate, and those values are added to the full range of CO_2 values.

D. Conclusion

DOE has tentatively concluded that, based upon clear and convincing evidence, the proposed standards for the CWH equipment classes evaluated in this rulemaking represent the maximum improvement in energy efficiency that is technologically feasible and economically justified, and would result in the significant additional conservation of energy. DOE further notes that equipment achieving these standard levels is already commercially available for all equipment classes covered by this proposal. Based on the analytical results described in this section, DOE has tentatively concluded that the benefits of the proposed standards to the Nation (*i.e.,* energy savings, positive NPV of commercial consumer benefits, commercial consumer LCC savings, and emission reductions) would outweigh the burdens (loss of INPV for manufacturers).

DOE also considered more-stringent energy efficiency levels as trial standard levels, 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 proposal, as well as some of the relevant historical background related to the establishment of standards for CWH equipment.

A. Authority

Title III, Part C [18] of the Energy Policy and Conservation Act of 1975 (''EPCA'' or ''the Act''), Public Law 94–163 (42 U.S.C. 6311–6317, as codified), added by Public Law 95–619, Title IV, § 441(a), established the Energy Conservation Program for Certain Industrial Equipment, which sets forth a variety of provisions designed to improve energy efficiency. These encompass several types of heating, air-conditioning, and water heating equipment, including the classes of CWH equipment that are the subject of this rulemaking.[19] (42 U.S.C. 6311(1)(K)) In general, this program addresses the energy efficiency of certain types of commercial and industrial equipment. Relevant provisions of the Act specifically include definitions (42 U.S.C. 6311), energy conservation standards (42 U.S.C. 6313), test procedures (42 U.S.C. 6314), labelling provisions (42 U.S.C. 6315), and the authority to require information and reports from manufacturers (42 U.S.C. 6316).

The initial Federal energy conservation standards and test procedures for CWH equipment were added to EPCA by the Energy Policy Act of 1992 (EPACT 1992), Public Law 102–486. (42 U.S.C. 6313(a)(5) and 42 U.S.C. 6314(a)(4)(A)) These initial CWH standards mirrored the levels and equipment classes in ASHRAE Standard 90.1–1989.

In acknowledgment of technological changes that yield energy efficiency benefits, the U.S. Congress further directed DOE through EPCA to evaluate and consider amending its energy conservation standards for certain commercial and industrial equipment (*i.e.,* specified heating, air-conditioning, and water heating equipment) each time ASHRAE Standard 90.1 is updated with respect to such equipment. (42 U.S.C. 6313(a)(6)(A)) Such review is to be conducted in accordance with the statutory procedures set forth in 42 U.S.C. 6313(a)(6)(B). Pursuant to 42 U.S.C. 6313(a)(6)(A), for CWH equipment, EPCA directs that if ASHRAE Standard 90.1 is amended, DOE must publish in the **Federal Register** an analysis of the energy savings potential of amended energy conservation standards within 180 days of the amendment of ASHRAE Standard 90.1. (42 U.S.C. 6313(a)(6)(A)(i)) EPCA further directs that DOE must adopt amended standards at the new efficiency level in ASHRAE Standard 90.1, unless clear and convincing evidence supports a determination that adoption of a more-stringent level would produce significant additional energy savings and be technologically feasible and economically justified. (42 U.S.C. 6313(a)(6)(A)(ii)) If DOE decides to adopt as a national standard the efficiency levels specified in the amended ASHRAE Standard 90.1, DOE must establish such standard not later than 18 months after publication of the amended industry standard. (42 U.S.C. 6313(a)(6)(A)(ii)(I)) If DOE determines that a more-stringent standard is appropriate under the statutory criteria, DOE must establish such more-stringent standard not later than 30 months after publication of the revised ASHRAE Standard 90.1. (42 U.S.C. 6313(a)(6)(B)(i))

In addition, DOE notes that pursuant to the EISA 2007 amendments to EPCA, the agency must periodically review its already-established energy conservation standards for covered ASHRAE equipment and publish either a notice of proposed rulemaking with amended standards or a determination that the standards do not need to be amended. (42 U.S.C. 6313(a)(6)(C)(i)) In December 2012, this provision was further amended by AEMTCA to clarify that DOE's periodic review of ASHRAE equipment must occur ''[e]very six years.'' (42 U.S.C. 6313(a)(6)(C)(i)) AEMTCA also modified EPCA to specify that any amendments to the design requirements with respect to the ASHRAE equipment would trigger DOE review of the potential energy savings under 42 U.S.C. 6313(a)(6)(A)(i). AEMTCA also added a requirement that DOE must initiate a rulemaking to consider amending the energy conservation standards for any covered equipment for which more than 6 years has elapsed since the issuance of the most recent final rule establishing or amending a standard for the product as of the date of AEMTCA's enactment (*i.e.,* December 18, 2012), in which case DOE must publish either: (1) a notice of determination that the current standards do not need to be amended, or (2) a notice of proposed rulemaking containing proposed standards. (42 U.S.C. 6313(a)(6)(C)(vi))

DOE published the most recent final rule for energy conservation standards for CWH equipment on January 12, 2001 (''January 2001 final rule''), which adopted efficiency levels in ASHRAE Standard 90.1–1999. 66 FR 3336, 3356. Because more than 6 years have passed since issuance of the last final rule for CWH equipment, DOE is required to publish either a notice of determination that the current standards for these equipment types do not need to be amended, or a notice of proposed rulemaking proposing amended energy conservation standards for these equipment types.

When setting standards for the equipment addressed by this document, EPCA, as amended by AEMTCA, prescribes specific statutory criteria for DOE to consider when determining whether an amended standard level more stringent than that in ASHRAE Standard 90.1 is economically justified. See generally 42 U.S.C. 6313(a)(6)(A)–(C). First, EPCA requires that any amended standards for CWH equipment must be designed to achieve significant additional conservation of energy that DOE determines, supported by clear and convincing evidence, and be both technologically feasible and economically justified. (42 U.S.C. 6313(a)(6)(A)(ii)(II) and (C)) Furthermore, DOE may not adopt any standard that would increase the maximum allowable energy use or decrease the minimum required energy efficiency of covered equipment. (42 U.S.C. 6313(a)(6)(B)(iii)(I) and (C)(i)) In deciding whether a proposed standard is economically justified, DOE must determine whether the benefits of the standard exceed its burdens by considering, to the maximum extent

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

[19] All references to EPCA in this document refer to the statute as amended through the Energy Efficiency Improvement Act of 2015 (EEIA 2015), Public Law 114–11 (April 30, 2015).

practicable, the following seven statutory factors:

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

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

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

(6) The need for national energy conservation; and

(7) Other factors the Secretary considers relevant.

(42 U.S.C. 6313(a)(6)(B)(ii) and (C)(i))

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) Specifically, EPCA requires that if a test procedure referenced in ASHRAE Standard 90.1 is updated, DOE must update its test procedure to be consistent with the amended test procedure in ASHRAE Standard 90.1, unless DOE determines that the amended test procedure is not reasonably designed to produce test results that reflect the energy efficiency, energy use, or estimated operating costs of the ASHRAE equipment during a representative average use cycle. In addition, DOE must determine that the amended test procedure is not unduly burdensome to conduct. (42 U.S.C. 6314(a)(2) and (4)) Manufacturers of covered equipment must use the prescribed DOE test procedure as the basis for certifying to DOE that their equipment complies with the applicable energy conservation standards adopted under EPCA and when making representations to the public regarding the energy use or efficiency of such equipment. (42 U.S.C. 6314(d)) Similarly, DOE must use these test procedures to determine whether the equipment complies with standards adopted pursuant to EPCA. The DOE test procedure for CWH equipment currently appears at 10 CFR 431.106.

EPCA, as codified, also contains what is known as an ''anti-backsliding'' provision, which prevents the Secretary from prescribing any amended standard that either increases the maximum allowable energy use or decreases the minimum required energy efficiency of a covered product. (42 U.S.C. 6313(a)(6)(B)(iii)(I) and (C)(i)) Furthermore, 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 of 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 at the time of the Secretary's finding. (42 U.S.C. 6313(a)(6)(B)(iii)(II)(aa) and (C)(i))

Further, EPCA, as codified, establishes a rebuttable presumption that a standard is economically justified if the Secretary finds that the additional costs to the consumer of purchasing a product complying with an energy conservation standard level will be less than three times the value of the energy (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.

Additionally, EPCA specifies criteria when promulgating a standard for a type or class of covered equipment that has two or more subcategories that may justify different standard levels. DOE must specify a different standard level than that which applies generally to such type or class of equipment for any group of covered products that has the same function or intended use if DOE determines that products within such group: (A) consume a different kind of energy from that consumed by other covered products within such type (or class); or (B) have a capacity or other performance-related feature which other products within such type (or class) do not have and which justifies a higher or lower standard. In determining whether a performance-related feature justifies a different standard for a group of products, DOE generally considers such factors as the utility to the commercial consumer of the feature and other factors DOE deems appropriate. In a rule prescribing such a standard, DOE includes an explanation of the basis on which such higher or lower level was established. DOE considered these criteria in the context of this rulemaking.

Other than the exceptions specified in 42 U.S.C. 6316, Federal energy conservation requirements generally supersede State laws or regulations concerning energy conservation testing, labeling, and standards for covered CWH equipment. (42 U.S.C. 6316(b))

B. Background

1. Current Standards

As noted above, DOE most recently amended energy conservation standards for certain CWH equipment in the July 2015 ASHRAE equipment final rule. 80 FR 42614, 42667 (July 17, 2015). The current standards for all CWH equipment classes are set forth in Table II.1.

TABLE II.1—CURRENT FEDERAL ENERGY CONSERVATION STANDARDS FOR CWH EQUIPMENT

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)

TABLE II.1—CURRENT FEDERAL ENERGY CONSERVATION STANDARDS FOR CWH EQUIPMENT—Continued

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 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 an 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.C.5.

2. History of Standards Rulemaking for CWH Equipment

The Energy Policy Act of 1992 (EPACT), Public Law 102–486, amended EPCA to prescribe mandatory energy conservation standards for CWH equipment, including storage water heaters, instantaneous water heaters, and unfired hot water storage tanks. (42 U.S.C. 6313(a)(5)) These statutory energy conservation standards corresponded to the efficiency levels in ASHRAE Standard 90.1–1989.

As noted in section II.A of this document, 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. DOE adopted the levels in ASHRAE Standard 90.1–1999 for all types 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. *Id.* at 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. *Id.* at 3356.

As noted above, ASHRAE increased the thermal efficiency level for commercial oil-fired storage water heaters greater than 105,000 Btu/h and less than 4,000 Btu/h/gal in Standard 90.1–2013, thereby triggering DOE's statutory obligation to promulgate an amended uniform national standard at those levels, unless DOE determines that there is clear and convincing evidence supporting the adoption of more-stringent energy conservation standards than the ASHRAE levels. As a first step in this process, DOE published an energy savings analysis as a Notice of Data Availability (NODA) in the **Federal Register** on April 11, 2014. 79 FR 20114. In this NODA, DOE tentatively decided that energy savings were not significant enough to justify further analysis of increasing standards for commercial oil-fired storage water heaters beyond the standard levels in ASHRAE 90.1–2013. DOE published a notice of proposed rulemaking in the **Federal Register** on January 8, 2015, which took a consistent position vis-à-vis commercial oil-fired storage water heaters. 80 FR 1172. Subsequently, in the 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 90.1–2013. 80 FR 42614 (July 17, 2015). This adopted standard is shown in Table II.2.

TABLE II.2—FEDERAL ENERGY CONSERVATION STANDARDS FOR THERMAL EFFICIENCY FOR COMMERCIAL OIL-FIRED STORAGE WATER HEATERS

Regulatory requirement	Input capacity/stored volume btu/(gal × h)	Thermal efficiency (%)	Compliance date
Previous Federal Standard	<4,000	78	10/29/2003.

TABLE II.2—FEDERAL ENERGY CONSERVATION STANDARDS FOR THERMAL EFFICIENCY FOR COMMERCIAL OIL-FIRED STORAGE WATER HEATERS—Continued

Regulatory requirement	Input capacity/stored volume btu/(gal × h)	Thermal efficiency (%)	Compliance date
Amended Federal Standard (ASHRAE 90.1–2013 Level)	<4,000	80	10/09/2015.

In addition to requiring rulemaking when triggered by ASHRAE action, EPCA also requires DOE to conduct an evaluation of its standards for CWH equipment every 6 years, and to publish either a notice of determination that such standards do not need to be amended or a notice of proposed rulemaking, including proposed amended standards. (42 U.S.C. 6313(a)(6)(C)(i)) Pursuant to this statutory requirement, DOE initiated this rulemaking to evaluate the energy conservation standards for covered CWH equipment and to determine whether new or amended standards are warranted. As an initial step for reviewing energy conservation standards for CWH equipment, DOE published a request for information for CWH equipment on October 21, 2014 (''October 2014 RFI''). 79 FR 62899. The October 2014 request for information (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. *Id.* at 62899–900.

DOE received a number of comments from interested parties in response to the October 2014 RFI. These commenters are identified in Table II.3. DOE considered these comments in the preparation of this NOPR. In this document, DOE addresses the relevant public comments it received in the appropriate sections.

TABLE II.3—INTERESTED PARTIES PROVIDING WRITTEN COMMENTS ON THE CWH RFI

Name	Abbreviation	Commenter type*
A.O. Smith Corporation	A.O. Smith	M
Bradford White Corporation	Bradford White	M
American Gas Association	AGA	IR
Air-Conditioning, Heating and Refrigeration Institute	AHRI	IR
Steffes Corporation	Steffes	M
Appliance Standards Awareness Project, American Council for an Energy-Efficient Economy, Natural Resources Defense Council.	Joint Advocates (including ASAP, ACEEE, and NRDC).	EA
Edison Electric Institute	EEI	IR
University of Michigan Plant Operations	UM	OS
Rheem Corporation	Rheem	M
National Rural Electric Cooperative Association	NRECA	IR

* ''IR'': Industry Representative; ''M'': Manufacturer; ''EA'': Efficiency/Environmental Advocate; ''OS'': Other Stakeholder.

III. General Discussion

A. Compliance Dates

In 42 U.S.C. 6313(a), EPCA prescribes a number of compliance dates for any resulting amended standards for CWH equipment. These compliance dates vary depending on specific statutory authority under which DOE is conducting its review (*i.e.,* whether DOE is triggered by a revision to ASHRAE Standard 90.1 or whether DOE is undertaking a ''6-year look back'' review), and the action taken (*i.e.,* whether DOE is adopting ASHRAE Standard 90.1 levels or more-stringent levels). The discussion that follows explains the potential compliance dates as they pertain to this rulemaking.

As noted previously, EPCA requires that at least once every 6 years, DOE must review standards for covered equipment and publish either a notice of determination that standards do not need to be amended or a NOPR proposing new standards. (42 U.S.C 6313(a)(6)(C)(i)) For any NOPR published pursuant to 42 U.S.C. 6313(a)(6)(C), the final rule would apply on the date that is the later of: (1) The date 3 years after publication of the final rule establishing a new standard or (2) the date 6 years after the effective date of the current standard for a covered product. (42 U.S.C. 6313(a)(6)(C)(iv)) For the CWH equipment for which DOE is proposing amended standards, the date 3 years after the publication of the final rule would be later than the date 6 years after the effective date of the current standard. As a result, compliance with any amended energy conservation standards, if adopted by a final rule in this rulemaking, would be required beginning on the date 3 years after the publication of the final rule.

B. Test Procedures

DOE's existing test procedure for CWH equipment is specified at 10 CFR 431.106, and incorporates by reference American National Standards Institute (ANSI) Standard Z21.10.3–2011 (ANSI Z21.10.3–2011), ''Gas Water Heaters, Volume III, Storage Water Heaters With Input Ratings Above 75,000 Btu Per Hour, Circulating and Instantaneous.'' The test procedure provides mandatory methods for determining the thermal efficiency and standby loss of certain classes of CWH equipment. In 10 CFR 431.104, DOE provides two sources for guidance on how to determine R-value of unfired hot water storage tanks.

On October 21, 2004, DOE published a direct final rule in the **Federal Register** that 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 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.

AEMTCA amended EPCA to require that DOE publish a final rule establishing a uniform efficiency descriptor and accompanying test methods for covered residential water heaters and certain CWH equipment. (42 U.S.C. 6295(e)(5)(B)) The final rule must replace the current energy factor (for residential 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)) AEMTCA allowed DOE to 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))

EPCA further requires that, along with developing a uniform descriptor, DOE must also 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 final rule, DOE interpreted these statutory requirements in 42 U.S.C. 6295(e)(5)(E) to mean that DOE must translate existing standards and ratings from the current metrics to the new metric, while maintaining the stringency of the current standards. 79 FR 40542, 40558 (July 11, 2014).

In the July 2014 final rule, DOE, among other things, established the uniform energy factor (UEF), 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 only applies to commercial water heaters that meet the definition of "residential-duty commercial water heater," which is defined as any gas-fired, electric, or oil-fired storage water heater or 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) Is not excluded by any of the specified limitations regarding rated input and storage volume shown in Table III.1, which reflects the table in 10 CFR 431.102.

Id. at 40586.

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 Storage.	Rated input >12 kW; Rated storage volume >120 gallons.
Heat Pump with Storage.	Rated input >12 kW; Rated current >24 A at a rated voltage of not greater than 250 V; Rated storage volume >120 gallons.
Gas-fired Instantaneous	Rated input >200 kBtu/h; Rated storage volume >2 gallons.
Electric Instantaneous	Rated input >58.6 kW; Rated storage volume >2 gallons.
Oil-fired Instantaneous	Rated input >210 kBtu/h; 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.

In April, 2016, DOE issued a NOPR proposing to amend the test procedures for certain other CWH equipment ("2016 CWH TP NOPR"). (See Docket No. EERE–2014–BT–TP–0008). In the 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 (including updating references from ANSI Z21.10.3–2011 to ANSI Standard Z21.10.3–2015 (ANSI Z21.10.3–2015), "Gas Water Heaters, Volume III, Storage Water Heaters With Input Ratings Above 75,000 Btu Per Hour, Circulating and Instantaneous"; (2) modifying the thermal efficiency and standby loss tests for certain classes of CWH equipment to improve repeatability; (3) developing a test method for determining the efficiency of unfired hot water storage tanks in terms of a standby loss metric; (4) changing the method for setting the thermostat for storage water heaters and storage-type instantaneous water heaters; (5) clarifying the thermal efficiency and standby loss test procedures with regard to stored energy loss and manipulation of settings during efficiency testing; (6) defining "storage-type instantaneous water heaters" and modifying several definitions for consumer water heaters and commercial water heating equipment included at 10 CFR 430.2 and 10 CFR 431.102, respectively; (7) developing a test procedure for measurement of standby loss for flow-activated instantaneous water heaters; (8) establishing temperature-sensing requirements for thermal efficiency and standby loss testing of instantaneous water heaters and hot water supply boilers; (9) modifying the standby loss test procedure for instantaneous water heaters and hot water supply boilers; (10) developing a test procedure for commercial heat pump water heaters; (11) establishing a procedure for determining the fuel input rate of gas-fired and oil-fired CWH equipment and clarifying DOE's enforcement provisions regarding fuel input rate; (12) modifying several definitions included in DOE's regulations for CWH equipment at 10 CFR 431.102; (13) establishing default values for certain testing parameters to be used if these parameters are not specified in product literature or supplemental test instructions; and (14) modifying DOE's certification requirements for CWH equipment. (See EERE–2014–BT–TP–0008) Discussion of DOE's treatment of unfired hot water storage tanks and commercial heat pump water heaters with respect to energy conservation standards can be found in sections III.C.4 and III.C.6, respectively.

For four classes of residential-duty commercial water heaters—electric storage water heaters, heat pump water heaters, gas-fired instantaneous water heaters, and oil-fired instantaneous water heaters—the input criteria established to separate residential-duty commercial water heaters and commercial water heaters are identical to those codified at 10 CFR 430.2 that separate consumer water heaters and commercial water heaters. Because these input criteria are identical, by definition, no models can be classified under these four residential-duty equipment classes. Therefore, to eliminate potential confusion, DOE proposed in the 2016 CWH TP NOPR to remove these classes from the definition for ''residential-duty commercial water heater'' codified at 10 CFR 431.102. (See EERE–2014–BT–TP–0008) For electric instantaneous water heaters, the rated maximum input criterion for residential-duty commercial water heaters is 58.6 kW, higher than 12 kW, which is the maximum input rate for residential electric instantaneous water heaters as defined in EPCA. (42 U.S.C. 6291(27)(B)) Therefore, there are models on the market that qualify as residential-duty commercial electric instantaneous water heaters. DOE's treatment of electric instantaneous water heaters in this rule is discussed in section III.C.5 of this document.

C. Scope of Rulemaking

In response to the 2014 RFI, DOE received several comments on the scope of this rulemaking. These comments cover specific equipment classes, as well as the improvement of overall water heating systems.

1. Commercial Water Heating Systems

The University of Michigan recommended that DOE fund research to develop best concepts for design, installation, and operation standards and codes. (UM, No. 9 at p. 3) [20] Additionally, Joint Advocates recommended that DOE consider that many CWH equipment systems are designed very inefficiently, citing unnecessary recirculation loops. (Joint Advocates, No. 7 at p. 2) Furthermore, the University of Michigan recommended that DOE approach the American Society of Mechanical Engineers (ASME) and ASHRAE to determine whether the scope of their existing standards can be expanded. (UM, No. 9 at p. 2)

In response, DOE notes that its Office of Energy Efficiency and Renewable Energy (EERE) already supports research and development in multiple areas of water-heating energy efficiency technology, including building codes and roadmaps for emerging water heating technologies.[21] In the context of this rulemaking, however, DOE must follow congressionally-mandated requirements and processes for setting standards and test procedures for CWH equipment, and DOE may not delegate its standard-setting responsibilities under the statute to ASME, ASHRAE, or any other organization. These processes are codified in the United States Code, Title 42, Chapter 77, Subchapter III, Part A—Energy Conservation Program for Consumer Products Other Than Automobiles and Part A–1—Certain Industrial Equipment. DOE notes that ASHRAE does set minimum efficiency levels for CWH equipment in ASHRAE Standard 90.1 and did recently update thermal efficiency levels for certain oil-fired CWH equipment as discussed in section II.B.2, but has not updated levels for other CWH equipment analyzed in this document within the last 6 years. DOE also notes that its energy conservation standards apply at the point of manufacture. DOE must consider energy conservation standards with respect to the CWH equipment as shipped from the manufacturer and using the statutory criteria contained in EPCA. DOE does not have authority to set standards for efficiency of installed CWH building systems.

2. Residential-Duty Commercial Water Heaters

DOE analyzed equipment classes for commercial water heaters and residential-duty commercial water heaters separately in this rulemaking. This rulemaking, therefore, includes CWH equipment classes that are covered by the UEF metric, as well as CWH equipment classes that continue to be covered by the existing thermal efficiency and standby loss metrics. However, DOE has conducted all analyses for selecting proposed standards in this document using the existing thermal efficiency and standby loss metrics, because there was no efficiency data in terms of UEF available when DOE undertook the analyses for this NOPR.

In the April 2015 NOPR, DOE proposed conversion factors to determine UEF for residential and residential-duty commercial water heaters from their current rated energy factor and thermal efficiency and standby loss values. 80 FR 20116, 20142–43 (April 14, 2015). For residential-duty commercial water heaters, conversion factors for determining UEF were proposed for the four draw patterns specified in the July 2014 test procedure final rule: high, medium, low, and very small. *Id.* at 20143. DOE then converted standard levels proposed in this NOPR for residential-duty commercial water heaters based upon the thermal efficiency and standby loss metrics to standards based upon the UEF metric, using the conversion factors proposed in the April 2015 NOPR. This conversion of standards from thermal efficiency and standby loss to UEF is described in further detail in section IV.C.9 of this NOPR.

3. 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 because DOE determined that there was insufficient potential for energy savings to justify further increasing the standard. 80 FR 42614 (July 17, 2015). Therefore, because thermal efficiency standards for commercial oil-fired storage water heater were just recently addressed in a separate rulemaking under the ASHRAE trigger, DOE did not consider further increasing thermal efficiency standards for commercial oil-fired storage water heaters in this rulemaking, as circumstances have not changed appreciably regarding this equipment during the intervening period. Consequently, this equipment class was not included in any of the analyses described in this document. For this NOPR, DOE also considered whether amended standby loss standards for commercial oil-fired water heaters would be warranted. DOE has tentatively concluded that a change in the maximum standby loss level would likely effect less of a change to energy consumption of oil-fired storage water heaters than would a change in the thermal efficiency. Therefore, an amended standby loss standard is

[20] A notation in this form provides a reference for information that is in the docket of DOE's rulemaking to develop energy conservation standards for commercial water heating equipment (Docket No. EERE–2014–BT–STD–0042, which is maintained at *http://www.regulations.gov/#!docketDetail;D=EERE-2014-BT-STD-0042*). This particular notation refers to a comment; (1) submitted by UM; (2) appearing in document number 0009; and (3) appearing on page 3 of that document.

[21] For an overview of DOE's energy efficiency related research, see *http://energy.gov/eere/efficiency*.

unlikely to result in significant additional energy savings. Thus, DOE has not analyzed amended standby loss standards for commercial oil-fired storage water heaters in this rulemaking. Similarly, DOE considered oil-fired instantaneous water heaters and hot water supply boilers, and did not identify any units currently on the market that would meet the DOE definition. Therefore, DOE estimates that there are very few, if any, annual shipments for this equipment class. Therefore, DOE has tentatively concluded that the energy savings possible from amended standards for such equipment is *de minimis,* and thus, did not analyze amended standards for commercial oil-fired instantaneous water heaters for this NOPR.

Issue 1: DOE seeks comment on its tentative conclusions regarding the potential energy savings from analyzing amended standards for standby loss of commercial oil-fired storage water heaters and for thermal efficiency of commercial oil-fired instantaneous water heaters.

4. Unfired Hot Water Storage Tanks

The current Federal energy conservation standard for unfired hot water storage tanks is expressed as an R-value requirement for the tank thermal insulation. In the 2016 CWH TP NOPR, DOE proposed a new test procedure for unfired hot water storage tanks using a new standby loss metric, which would replace the current R-value requirement. (See EERE–2014–BT–TP–0008) In the October 2014 RFI, DOE stated that any amended energy conservation standards for unfired hot water storage tanks would be in terms of the metric to be established in the noted test procedure rulemaking. 79 FR 62899, 62903 (Oct. 21, 2014). Given the lack of testing data for the new metric and test procedure proposed in the 2016 CWH TP NOPR, DOE plans to consider energy conservation standards for unfired hot water storage tanks in a separate rulemaking. Therefore, DOE did not evaluate potential amendments to standards for unfired hot water storage tanks in this NOPR.

5. Electric Instantaneous Water Heaters

EPCA prescribes energy conservation standards for several classes of commercial water heating equipment manufactured on or after January 1, 1994. (42 U.S.C. 6313(a)(5)) DOE codified these standards in its regulations for commercial water heating 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, DOE proposes to codify these standards in its regulations at 10 CFR 431.110.

DOE received several comments on the analysis of commercial electric instantaneous water heaters. A.O. Smith stated that commercial electric instantaneous water heaters should be included in the scope of this rulemaking. (A.O. Smith, No. 2 at p. 1) Similarly, Bradford White and AHRI stated that electric instantaneous units should be included in the scope of this rulemaking, in separate equipment classes. (Bradford White, No. 3 at p. 1; AHRI, No. 5 at p. 2)

Rheem stated that electric instantaneous water heaters should not be included in the scope of this rulemaking because of the limited applications of this equipment. (Rheem, No. 10 at p. 1) Joint Advocates recommended that electric instantaneous water heaters not be included in this rulemaking, unless there is evidence of particularly inefficient models on the market. (Joint Advocates, No. 7 at p. 3)

While it is within the Department's authority to propose amended standards for electric instantaneous water heaters, DOE has tentatively concluded that there is little potential for additional energy savings from doing so. The thermal efficiency of electric instantaneous water heaters is already at nearly 100 percent due to the high efficiency of electric resistance heating elements, thus providing little reason to propose an amended standard for this equipment class. Additionally, DOE tentatively concluded that amending the standby loss standard for this class would result in minimal energy savings.

6. Commercial Heat Pump Water Heaters

A.O. Smith also stated that commercial heat pump water heaters, of add-on, integrated, air-source, and water-source categories, should be included in the scope of this rulemaking. (A.O. Smith, No. 2 at p. 1) Similarly, Bradford White, Rheem, and AHRI stated that add-on, integrated, air-source, and water-source heat pump water heaters should be included in this rulemaking. (Bradford White, No. 3 at p. 1; Rheem, No. 10 at p. 1; AHRI, No. 5 at p. 2) Rheem also commented that integrated and add-on heat pump water heaters differ by construction, application, life-cycle cost, and energy consumption, and that both air-source and water-source heat pump water heaters are currently available on the market. AHRI also commented that electric instantaneous water heaters and heat pump water heaters should be considered as separate equipment classes, and that if integrated heat pump water heaters are not included, then units falling outside of the definition for residential heat pump water heaters will go unregulated.

Joint Advocates stated that DOE should develop a test procedure for both integrated and add-on commercial heat pump water heaters. Joint Advocates stated that such a test procedure should have low enough operating temperature conditions to gauge whether units operate in electric resistance heating mode during cold weather, and that a DOE test procedure would help grow the market by allowing for greater use of rebate programs. Joint Advocates also commented that air-source units should be included, but that inclusion of water-source units would be complicated due to varying inlet water conditions for water-source and ground-source applications. (Joint Advocates, No. 7 at p. 3)

While DOE agrees that integrated, add-on, and air-source and water-source commercial heat pump water heaters meet EPCA's definitions for commercial storage and instantaneous water heaters, DOE is not proposing amended standards for any of these classes of commercial heat pump water heaters in this NOPR. DOE has found no evidence of any commercial integrated heat pump water heaters on the market. All commercial heat pump water heaters that DOE identified as currently on the market are ''add-on'' units, which are designed to be paired with either an electric storage water heater or unfired hot water storage tank in the field.

As discussed in section III.B, a test procedure for commercial heat pump water heaters was proposed in the 2016 CWH TP NOPR. (See EERE–2014–BT–TP–0008) Because the test procedure has not yet been established in a final rule and there is not sufficient test data with the proposed test method for units currently on the market, DOE plans to consider energy conservation standards for commercial heat pump water heaters in a future rulemaking.

7. Electric Storage Water Heaters

DOE did not include electric storage water heaters in the analysis of amended thermal efficiency standards. Electric storage water heaters do not currently have a thermal efficiency requirement under 10 CFR 431.110. Electric storage water heaters typically use electric resistance coils as their heating elements, which are highly efficient. The thermal efficiency of these units already approaches 100 percent. Therefore, there are no options for increasing the rated thermal efficiency of this equipment, and the impact of setting thermal efficiency energy conservation standards for these products would be negligible. However, DOE has considered amended standby loss standards for electric storage water heaters.

8. Instantaneous Water Heaters and Hot Water Supply Boilers

In its analysis of amended standby loss standards, DOE did not include instantaneous water heaters and hot waters supply boilers other than storage-type instantaneous water heaters.[22] Instantaneous water heaters and hot waters supply boilers other than storage-type instantaneous water heaters with greater than 10 gallons of water stored do 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 tentatively determined that such amended standards would result in minimal energy savings. DOE identified only 26 models on the market of instantaneous water heaters or hot water supply boilers with greater than 10 gallons of water stored (other than storage-type instantaneous water heaters), and 14 of the identified models have less than 15 gallons of water stored. DOE tentatively concluded that hot water supply boilers with less than 10 gallons would not have significantly different costs and benefits as compared to hot water supply boilers with greater than 10 gallons. Therefore, DOE analyzed both equipment classes of instantaneous water heaters and hot water supply boilers (less than 10 gallons and greater than 10 gallons stored volume) together for thermal efficiency standard levels in this NOPR.

[22] DOE proposed a definition for ''storage-type instantaneous water heater'' in the 2016 CWH TP NOPR. (See EERE–2014–BT–TP–0008) Storage-type instantaneous water heaters are discussed in section IV.A.2.a of this NOPR.

DOE also tentatively determined that establishing standby loss standards for instantaneous water heaters and hot water supply boilers with less than or equal to 10 gallons waters stored would result in minimal energy savings.

D. Technological Feasibility

1. General

In each energy conservation standards rulemaking, DOE conducts a screening analysis based on information gathered on all current technology options and prototype designs that could improve the efficiency of the products or equipment that is the subject of the rulemaking. As the first step in such an analysis, DOE conducts a market and technology assessment that develops a list of technology options for consideration in consultation with manufacturers, design engineers, and other interested parties. DOE then determines which of those means for improving efficiency are technologically feasible. DOE considers technologies incorporated in commercially-available equipment or in working prototypes to be technologically feasible. 10 CFR part 430, subpart C, appendix A, section 4(a)(4)(i).

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. 10 CFR part 430, subpart C, appendix A, section 4(a)(4)(ii)–(iv). Additionally, DOE notes that the four screening criteria do not directly address the propriety status of design options. DOE only considers efficiency levels achieved through the use of proprietary designs in the engineering analysis if they are not part of a unique path to achieve that efficiency level (*i.e.,* if there are other non-proprietary technologies capable of achieving the same efficiency). 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 trial standard levels (TSLs) in this rulemaking. For further details on the screening analysis for this rulemaking, see chapter 4 of the NOPR technical support document (TSD).

2. Maximum Technologically Feasible Levels

When DOE proposes to adopt an amended standard for a type or class of covered equipment, it must determine 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 maximum technologically feasible (''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 rulemaking are described in section IV.C.3.b of this proposed rule. Chapter 5 of the NOPR TSD includes more detail on the selected max-tech efficiency levels.

E. Energy Savings

1. Determination of Savings

For each TSL, DOE projected energy savings from the classes of equipment that are the subjects of this rulemaking shipped in the 30-year period that begins in the year of compliance with amended standards (2019–2048 for gas-fired CWH equipment and electric CWH equipment).[23] The savings are measured over the entire lifetime of equipment shipped in the 30-year analysis period.[24] DOE quantified the energy savings attributable to each TSL as the difference in energy consumption between standards and no-new-standards cases. The no-new-standards case represents a projection of energy consumption in the absence of amended mandatory energy conservation standards, and it considers market forces and policies that affect current demand for more-efficient equipment over the analysis period.

DOE used its national impact analysis (NIA) spreadsheet model to estimate national energy savings (NES) from potential amended standards for commercial water heating 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 electric commercial water heaters, DOE calculates NES on an annual basis in

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

[24] In the past, DOE presented energy savings results for only the 30-year period that begins in the year of compliance. In the calculation of economic impacts, however, DOE considered operating cost savings measured over the entire lifetime of equipment shipped in the 30-year period. DOE has chosen to modify its presentation of national energy savings to be consistent with the approach used for its national economic analysis.

terms of primary energy[25] savings, which is the savings in the energy that is used to generate and transmit the site electricity. To calculate primary energy savings from site electricity savings, DOE derived annual conversion factors from the model used to prepare the Energy Information Administration (EIA)'s *AEO 2015.* For natural gas- and oil-fired commercial water heaters, the primary energy savings are considered equal to the site energy savings because they are supplied to the user without transformation from another form of energy.

In addition to primary energy savings, DOE also calculates full-fuel-cycle (FFC) energy savings. As discussed in DOE's statement of policy and notice of policy amendment, 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. 76 FR 51281 (August 18, 2011), as amended at 77 FR 49701 (August 17, 2012). For FFC energy savings, DOE's approach is based on the calculation of an FFC multiplier for each of the energy types used by covered equipment.[26] For more information, see section IV.H.2 of this document.

Issue 2: The agency assumes no growth in equipment efficiency in absence of new standards; however, DOE requests comment on expected changes over the analysis period in market share by energy efficiency level or average shipment-weighted efficiency for the analyzed CWH equipment classes in the no-new-standards case.

2. Significance of Savings

To amend standards for commercial water heating equipment, DOE must determine with clear and convincing evidence that the standards would result in ''significant'' additional energy savings. (42 U.S.C. 6313(a)(6)(A)(ii)(II) and (C)(i)) Although the term ''significant'' is not defined in the Act, the U.S. Court of Appeals for the District of Columbia Circuit, in *Natural Resources Defense Council* v. *Herrington,* 768 F.2d 1355, 1373 (D.C. Cir. 1985), indicated that Congress intended ''significant'' energy savings in this context to be savings that were not ''genuinely trivial.'' The energy savings for all of the TSLs considered in this rulemaking, including the proposed standards (presented in section V.C.1), are nontrivial. Therefore, DOE has tentatively concluded that the energy savings associated with the proposed standards in this NOPR—1.8 quads due to commercial water heating equipment shipped in 2019–2048—are ''significant,'' as required by 42 U.S.C. 6313(a)(6)(A)(ii)(II) and (C)(i).

F. Economic Justification

1. Specific Criteria

EPCA provides seven factors to be evaluated in determining whether a potential energy conservation standard for commercial water heating 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 conducts a manufacturer impact analysis (MIA), as discussed in section IV.J of this NOPR. 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).[27] The industry-wide impacts analyzed include: (1) Industry net present value (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 commercial water heating 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) and (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 a distribution of values, with probabilities attached to each value. For its analysis, DOE assumes that commercial consumers will purchase the covered equipment in the first year of compliance with amended standards.

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

The LCC savings 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

[25] Primary energy consumption refers to the direct use at source, or supply to users without transformation, of crude energy; that is, energy that has not been subjected to any conversion or transformation process.

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

[27] 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.

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) and (C)(i)) As discussed in section IV.H 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 products, 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 products likely to result from the standard. (42 U.S.C. 6313(a)(6)(B)(ii)(IV) and (C)(i)) Based on data available to DOE, the standards proposed in this document would not reduce the utility or performance of the CWH equipment under consideration in this rulemaking. Section IV.B of this document and Chapter 4 of the NOPR TSD provide detailed discussion on the potential impact of amended standards on equipment utility and performance.

e. Impact of Any Lessening of Competition

EPCA directs DOE to consider any lessening of competition that is likely to result from energy conservation standards. It also directs the Attorney General of the United States (Attorney General) to determine the impact, if any, of lessening of competition likely to result from a proposed standard and to transmit such determination in writing to the Secretary, together with an analysis of the nature and extent of such impact. (42 U.S.C. 6313(a)(6)(B)(ii)(V) and (C)(i)) To assist the Attorney General in making such determination, DOE will transmit a copy of this proposed rule and the TSD to the Attorney General for review with a request that the Department of Justice (DOJ) provide its determination on this issue. DOE will publish and address 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

In considering new or amended energy conservation standards, EPCA also directs DOE to consider the need for national energy conservation. (42 U.S.C. 6313(a)(6)(B)(ii)(VII) and (C)(i)) DOE expects that the energy savings from the proposed standards are likely to provide improvements to the security and reliability of the nation's energy system. Reductions in the demand for electricity also may result in reduced costs for maintaining the nation's electricity system. DOE conducts a utility impact analysis to estimate how standards may affect the nation's needed power generation capacity, as discussed in section IV.M.

The proposed standards also are likely to result in environmental benefits in the form of reduced emissions of air pollutants and greenhouse gases associated with energy production. DOE reports the emissions impacts from the proposed standards of this rulemaking, and from each TSL it considered, in sections IV.K and V.B.6 of this NOPR. DOE also reports estimates of the economic value of emissions reductions resulting from the considered TSLs, as discussed in section IV.L of this NOPR.

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 proposed energy conservation standards would have on the payback period for commercial consumers. These analyses include, but are not limited to, the 3-year payback period contemplated under the rebuttable-presumption test.

In addition, DOE routinely conducts an economic analysis that considers the full range of impacts to commercial consumers, manufacturers, the Nation, and the environment, as required under 42 U.S.C. 6313(a)(6)(B)(ii) and (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 proposed rule.

G. Public Participation

UM commented that because of the number of issues on which DOE seeks comment, only stakeholders who have staff dedicated to regulatory processes would be able to comment on all issues involved in this rulemaking. (UM, No. 9 at p. 1) UM stated that a large rulemaking like this one favors trade associations over end users who have limited means to respond. UM recommended that DOE break up the rulemaking into smaller, more manageable pieces, thereby allowing more stakeholders to provide comments. (UM, No. 9 at p. 2)

DOE notes that pursuant to EPCA requirements, DOE provides an equal opportunity for the public to provide comment in response to rulemaking notices published in the **Federal Register** or during DOE rulemaking public meetings. DOE solicits data and information throughout the rulemaking process to validate and improve its analyses. Although DOE welcomes comments on any aspect of a rulemaking notice, to better facilitate public comments, DOE clearly lists the issues on which it is particularly interested in receiving comments and views of interested parties, as shown in section VII.E of this document. All stakeholders may comment on any or all of the issues so that their relevant views are considered in DOE's analysis. Furthermore, to offer enough time for the public to respond, DOE typically provides 60 days for the public to provide comment after publication of a NOPR for energy conservation standards. Therefore, DOE believes it provides the interested public an equal opportunity and adequate time to respond to a rulemaking without being overly burdensome for commenters.

In addition, DOE disagrees with UM's assertion that its rulemaking public participation process disproportionally benefits certain groups over end users. All stakeholders' views, data, and other relevant information are taken into account in developing and implementing final regulations. DOE is also statutorily mandated to evaluate the impact on commercial consumers that could be potentially affected by increased standards. As detailed in sections III.F.1, IV.F, and V.B.1 of this document, DOE thoroughly evaluates the impact on commercial consumers in determining whether a proposed standard is economically justified. Therefore, DOE believes comments from end users of covered equipment are equally and appropriately considered in this rulemaking.

In response to UM's comments regarding breaking the rulemaking into smaller pieces, DOE clarifies that its rulemaking notices already separate the analysis into analytical subsections as shown in sections III, IV, and V of this document. In each analytical subsection, DOE presents the applicable analytical tools, resources, and data used for the analysis. DOE also clarifies the issues pertaining to the analysis on which it seeks public comment in each subsection. Therefore, DOE views the current structure of its rulemaking notices as sufficient to allow the public to consider and provide comment on specific sections of its rulemaking. As with all rulemakings, DOE encourages stakeholder review and feedback on the analyses described in this NOPR and in the NOPR TSD.

H. Revisions to Notes in Regulatory Text

DOE proposes to modify the three notes to the table of energy conservation standards in 10 CFR 431.110. First, DOE proposes 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 2016 CWH TP NOPR. Among these changes, DOE proposed that the fuel input rate be used to determine equipment classes and calculate the standby loss standard. (See EERE–2014–BT–TP–0008) Therefore, in this NOPR, DOE proposes to replace the term ''nameplate input rate'' with the term ''fuel input rate.''

Additionally, DOE proposes to remove the note to the table of energy conservation standards denoted by subscript ''b.'' This note clarifies the compliance dates for energy conservation standards for units manufactured after 2005 and between 2003 and 2005. DOE has determined that this note is no longer needed because both of these compliance dates are over 10 years before the compliance date of standards proposed in this NOPR.

DOE also proposes 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 proposes to replace the phrase ''fire damper'' with the phrase ''flue damper,'' because DOE believes that ''flue damper'' was the intended meaning, and that ''fire damper'' was a typographical error. DOE believes 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.

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

I. Certification, Compliance, and Enforcement Issues

1. Rated and Measured Storage Volume

In this NOPR, DOE proposes to make two changes to its certification, compliance, and enforcement regulations at 10 CFR Part 429. First, DOE proposes to add requirements to 10 CFR 429.44 that the rated value of storage tank volume must equal the mean of the measured storage volume of the units in the sample. 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 final rule, DOE established a requirement for residential 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 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 increases as rated storage volume increases. DOE believes commercial consumers often look to storage volume as a key factor in choosing a storage water heater. Consequently, DOE proposes to adopt rating requirements that the rated storage volume must be equal to the mean of the values measured using DOE's test procedure. In the 2016 CWH TP NOPR, DOE proposed a test procedure for measuring the storage volume of CWH equipment that is similar to the method contained in section 5.27 of ANSI Z21.10.3–2015. (See EERE–2014–BT–TP–0008) In addition, DOE proposes to specify that for DOE-initiated testing, the mean of the measured storage volumes must be within five 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 volumes is more than five percent different than the rated storage volume, then DOE proposes 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).

Issue 4: DOE requests comment on its proposed changes to its certification, compliance, and enforcement regulations requiring the rated volume to be equal to the mean of the measured volumes in a sample.

2. Maximum Standby Loss Equations

As discussed in section III.I.1, DOE proposes to add requirements to 10 CFR 429.44 that the rated value of storage tank volume must equal the mean of the measured storage volumes of the units in the sample. In addition, DOE proposes to specify that for DOE-initiated testing, a tested value within 5 percent of the rated value would be a valid test result, such that the rated storage volume would then be used in downstream calculations. If the test result of the volume is invalid (*i.e.,* the measured value is more than 5 percent different than the rated value), then DOE proposed to use the measured value in determining the applicable minimum energy conservation standard and calculations within the test procedure. Specifically, the storage volume is used to calculate standby loss for CWH equipment.

To be consistent with the proposed changes to its certification, compliance, and enforcement regulations, DOE has tentatively concluded that the maximum standby loss equations for CWH equipment should be set in terms of rated volume. The current standby loss standards for water heaters differ in the storage volume metric used in calculation of the standby loss standard (rated storage volume is used for certain classes, while measured storage volume is used for others). Specifically, the maximum standby loss equation for gas-fired and oil-fired water heaters depends on the rated storage volume of the water heater. However, the maximum standby loss equations for electric water heaters depends on the measured storage volume of the water heater. DOE notes there is often a difference between the measured and rated volumes of water heaters, as reported in data in the AHRI Directory. Therefore, DOE proposes to modify the maximum standby loss equations for electric water heaters to depend on rated volume. Specifically, DOE proposes to modify the maximum standby loss equation for electric storage water heaters as shown in the following equation.

$$S = 0.3 + \frac{27}{V_r}$$

Additionally, DOE proposes to modify the maximum standby loss equation for electric instantaneous water heaters with storage capacity greater than or equal to ten gallons as shown in the following equation. Further discussion of energy conservation standards for electric instantaneous water heaters is included in section III.C.5.

$$S = 2.30 + \frac{67}{V_r}$$

Issue 5: DOE requests comment on its proposed modification of the maximum standby loss equations for electric storage and instantaneous water heaters to depend on rated volume instead of measured volume.

IV. Methodology and Discussion of Related Comments

This section addresses the analyses DOE has performed for this rulemaking with regard to CWH equipment. A separate subsection addresses each component of the analyses.

In overview, DOE used several analytical tools to estimate the impact of the standards proposed in this document. The first tool is a spreadsheet that calculates the LCC and PBP of potential amended or new energy conservation standards. The national impacts analysis (NIA) uses a second spreadsheet set that provides shipments forecasts and calculates national energy savings and net present value resulting from potential new or amended energy conservation standards. DOE uses the third spreadsheet tool, the Government Regulatory Impact Model (GRIM), to assess manufacturer impacts of potential new or amended standards. These three spreadsheet tools are available on the DOE Web site for this rulemaking: *https://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 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 *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: (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 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 codified the following more specific definitions for CWH equipment in 10 CFR 431.102 in a final rule published in the **Federal Register** on October 21, 2004 (''October 2004 final rule''). 69 FR 61974, 61983.[30]

Specifically, DOE defined ''hot water supply boiler'' 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) has the temperature and pressure controls necessary for heating potable water for purposes other than space heating, and/or 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.[31]

DOE also defined an ''instantaneous water heater'' as a water heater that has an input rating not less than 4,000 Btu/h per gallon of stored water, and that is industrial equipment, including products meeting this description that are designed to heat water to temperatures of 180 °F or higher.[32]

[28] For more information on NEMS, refer to *The National Energy Modeling System: An Overview.* U.S. Energy Information Administration (EIA) (2009) DOE/EIA–0581(2009) (Available at: *www.eia.gov/oiaf/aeo/overview).*

[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.)

[30] In the 2016 CWH TP NOPR, DOE proposed to amend its definitions for commercial water heating equipment by changing the phrase ''input rating'' to ''fuel input rate'' for gas-fired and oil-fired equipment, in order to match DOE's proposed regulations regarding fuel input rate. (See EERE–2014–BT–TP–0008)

[31] In the 2016 CWH TP NOPR, DOE proposed to amend its definition for ''hot water supply boiler'' by citing the definition for ''packaged boiler'' included in § 431.82 instead of a duplicated definition for ''packaged boiler'' in § 431.102, which DOE proposed to remove. (See EERE–2014–BT–TP–0008)

[32] In the 2016 CWH TP NOPR, DOE proposed to amend its definition for ''instantaneous water heater'' by making the following changes: (1) Removing the clause stating that products designed to heat water to temperatures of 180 °F or higher are included; (2) removing the clause ''that is industrial equipment''; and (3) adding the input criteria that

Continued

DOE defined a ''storage water heater'' as a water heater that heats and stores water within the appliance at a thermostatically controlled temperature for delivery on demand and that is industrial equipment, and does not include units with an input rating of 4,000 Btu/h or more per gallon of stored water.[33]

Lastly, DOE defined an ''unfired hot water storage tank'' as a tank used to store water that is heated externally, and that is industrial equipment.

Id.

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.

DOE currently divides CWH equipment classes based on the energy source, equipment category (*i.e.,* storage vs. instantaneous and hot water supply boilers), and size (*i.e.,* input capacity rating and rated storage volume). Unfired hot water storage tanks are also included as a separate equipment class. Table IV.1 shows DOE's current CWH equipment classes and energy conservation standards.

TABLE IV.1—CURRENT CWH EQUIPMENT CLASSES AND ENERGY CONSERVATION STANDARDS

Equipment class	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 an 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.C.5.

Table IV.2 presents the proposed equipment classes for CWH equipment. The following text provides additional details, discussion of comments relating to the equipment classes, proposed definitions, as well as issues on which DOE is seeking comments.

TABLE IV.2 PROPOSED CWH EQUIPMENT CLASSES

Equipment class	Specifications*
Electric storage water heaters	All
Gas-fired storage water heaters:	
Commercial	Rated input >105 kBtu/h or rated storage volume >120 gal
Residential-Duty**	Rated input ≤105 kBtu/h and rated storage volume ≤120 gal
Oil-fired storage water heaters:	
Commercial	Rated input >140 kBtu/h or rated storage volume >120 gal
Residential-Duty**	Rated input ≤140 kBtu/h and rated storage volume ≤120 gal
Electric instantaneous water heaters †, ††	<10 gal
	≥10 gal

separate consumer and commercial instantaneous water heaters for each energy source (*i.e.,* gas, oil, and electricity). (See EERE–2014–BT–TP–0008)

[33] In the 2016 CWH TP NOPR, DOE proposed to amend its definition for ''storage water heater'' by adding the input criteria that separate consumer and commercial storage water heaters for each energy source (*i.e.,* gas, oil, and electricity). (See EERE–2014–BT–TP–0008)

TABLE IV.2 PROPOSED CWH EQUIPMENT CLASSES—Continued

Equipment class	Specifications*
Gas-fired instantaneous water heaters and hot water supply boilers ††	
Instantaneous water heaters (other than storage-type) and hot water supply boilers.	<10 gal ≥10 gal
Storage-type instantaneous water heaters †††	≥10 gal
Oil-fired instantaneous water heaters and hot water supply boilers ††	<10 gal ≥10 gal
Unfired hot water storage tanks	All

* These specifications only distinguish between classes of CWH equipment. The different classifications of consumer water heaters and commercial water heating equipment are specified by the definitions codified at 10 CFR 430.2 and 10 CFR 431.102, respectively.

** In addition to the listed specifications, to be classified as a residential-duty commercial 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).

† Energy conservation standards for electric instantaneous water heaters are included in EPCA. (42 U.S.C. 6313(a)(5)(D) (E)) In this NOPR, DOE proposes to codify these equipment classes and corresponding energy conservation 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.C.5.

†† To be considered an instantaneous water heater or hot water supply boiler, CWH equipment must heat greater than 4,000 Btu per gallon of water stored.

††† DOE proposes a new equipment class for storage-type instantaneous water heaters, which are similar to storage water heaters, but with a ratio of input capacity to storage volume greater than or equal to 4,000 Btu/h per gallon of water stored. DOE proposed a definition for ''storage-type instantaneous water heater'' in the 2016 CWH TP NOPR. (See EERE–2014–BT–TP–0008)

In the October 2014 RFI, DOE sought comment on several issues regarding the equipment class structure for CWH equipment. 79 FR 62899, 62904–09 (Oct. 21, 2014). In response, A.O. Smith, Bradford White, and AHRI all recommended that the equipment class structure be simplified by establishing the following equipment classes: (1) Commercial gas-fired water heaters and hot water supply boilers <10 gallons; (2) commercial-fired gas water heaters and hot water supply boilers ≥10 gallons; (3) commercial oil-fired water heaters and hot water supply boilers <10 gallons; and (4) commercial oil-fired water heaters and hot water supply boilers ≥10 gallons. (A.O. Smith, No. 2 at p. 1; Bradford White, No. 3 at p. 1; AHRI, No. 5 at p. 1)

DOE disagrees that the equipment class structure should be simplified in the manner the commenters suggested because commercial instantaneous water heaters and hot water supply boilers with a storage volume greater than 10 gallons would include units with significant variation in design and utility. Specifically, this equipment class currently contains both hot water supply boilers and storage-type water heaters with greater than 4,000 Btu/h per gallon of water stored, which DOE believes may require separate equipment classes for reasons detailed in the discussion immediately below. Therefore, DOE has tentatively concluded that instantaneous water heaters with a storage volume greater than 10 gallons and storage water heaters should remain in separate equipment classes.

a. Storage-Type Instantaneous Water Heaters

In the 2016 CWH TP NOPR, DOE noted that the ''gas-fired instantaneous water heaters and hot water supply boilers'' equipment class with a storage volume greater than or equal to 10 gallons 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). (See EERE–2014–BT–TP–0008) Therefore, DOE proposed to separate these units into classes—storage-type instantaneous water heaters with greater than 4,000 Btu/h per gallon of stored water, and instantaneous water heaters (other than storage-type) and hot water supply boilers with greater than 10 gallons of stored water, with the following definition for ''storage-type instantaneous water heater'':

Storage-type instantaneous water heater means an instantaneous water heater comprising a storage tank with a submerged heat exchanger(s) or heating element(s).

It is DOE's understanding 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 recovery capacity of the water heater. However, through a review of product literature, DOE noted no significant design differences that would warrant different energy conservation standard levels (for either thermal efficiency or standby loss) between models in these two proposed equipment classes. Therefore, DOE grouped the two equipment classes together in its analyses for this rulemaking. As a result, DOE proposes the same standard levels for commercial gas-fired storage water heaters and commercial gas-fired storage-type instantaneous water heaters.

Issue 6: DOE requests comment on whether there are significant differences between storage water heaters and storage-type instantaneous water heaters that would justify analyzing these classes separately for amended energy conservations standards.

b. Tankless Water Heaters and Hot Water Supply Boilers

DOE notes that there are also significant 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. Specifically, DOE has identified two kinds of equipment within this class: Tankless water heaters and hot water supply boilers. From examination of equipment literature and discussion with manufacturers, DOE understands 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. Because of these basic similarities, DOE continued to group these types of equipment into a single equipment class and 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 this NOPR.

Issue 7: DOE requests comment on 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. Additionally, DOE requests feedback on what criteria should be used to distinguish between tankless water heaters and hot water supply boilers if separate equipment classes are established.

DOE only considered gas-fired instantaneous water heaters and hot water supply boilers with an input capacity greater than 200,000 Btu/h in its analysis, because EPCA includes gas-fired instantaneous water heaters with an input capacity less than or equal to 200,000 Btu/h in its definition of consumer ''water heater.'' (42 U.S.C. 6291(27)(b))

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

A.O. Smith, Bradford White, Rheem, and AHRI commented that the current separation of commercial gas and oil storage water heaters into classes with input capacity less than or equal to 155,000 Btu/h and greater than 155,000 Btu/h is not needed, arguing that such distinction should be eliminated. (A.O. Smith, No. 2 at p. 1; Bradford White, No. 3 at p. 1; Rheem, No. 10 at p. 1; AHRI, No. 5 at p. 2)

DOE agrees with the commenters, and proposes to consolidate commercial gas-fired and oil-fired storage equipment classes that are currently divided by input rates of 155,000 Btu/h. DOE is now proposing the following two equipment classes without an input rate distinction: (1) Gas-fired storage water heaters and (2) oil-fired storage water heaters. The input rate of 155,000 Btu/h was first used as a dividing criterion for storage water heaters in the 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 divided by 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. Therefore, DOE tentatively concluded that eliminating the dividing criterion for commercial gas-fired and oil-fired storage water heaters at 155,000 Btu/h would simplify the equipment class structure and make the structure more consistent with that in ASHRAE Standard 90.1.

d. Grid-Enabled Water Heaters

A. O. Smith, Rheem, and AHRI suggested that DOE should adopt a separate equipment class for grid-enabled electric storage water heaters. (A.O. Smith, No. 2 at p. 1; Rheem, No. 10 at p. 1; AHRI, No. 5 at p. 1) NRECA stated that DOE should not adopt any standards that effectively eliminate water heating technologies used for demand response and thermal storage. (NRECA, No. 11 at p. 2) Steffes recommended establishing a sub-class for grid-interactive electric storage units, due to their different operating schedules and economic considerations. (Steffes, No. 6 at p. 2)

DOE tentatively concludes that a separate equipment class for grid-enabled commercial electric storage water heaters is not warranted. First, as discussed in section III.B, there are no units in the residential-duty electric storage equipment class, as the dividing criteria for residential and commercial electric storage units match those for residential-duty and commercial electric storage units. Therefore, electric storage water heaters can only be classified as residential or commercial, and an equipment class of grid-enabled residential-duty water heaters would comprise no units. Second, for commercial electric storage water heaters, DOE only prescribes a standby loss standard. DOE does not believe an increased standby loss standard level would be likely to affect grid-enabled technology because the more-stringent standby loss level analyzed for electric storage water heaters is most commonly met by increasing insulation thickness, which would not differentially affect grid-enabled technology. Therefore, DOE is not proposing a separate equipment class for grid-enabled commercial electric storage water heaters in this rulemaking.

e. Condensing Gas-Fired Water Heating Equipment

AGA suggested that DOE should analyze commercial gas condensing and non-condensing water heaters as separate equipment classes. (AGA, No. 4 at p. 2) AGA stated that replacement of non-condensing gas water heaters with condensing gas water heaters can be problematic due to the separate venting needed and condensate disposal issues. AGA opined that the ability of non-condensing gas water heaters to be common-vented with other gas appliances into chimneys is a performance feature that justifies analyzing non-condensing and condensing gas water heaters separately. AGA also cited precedent for such a separation in analysis in the residential clothes dryer energy conservation standards rulemaking.

Regarding the separation of vented and vent-less clothes dryers into two product classes in the residential clothes dryer rulemaking as cited by AGA, DOE has found the circumstances in that rulemaking to be distinguishable from the present rulemaking. More specifically, in a direct final rule for energy conservation standards for residential clothes dryers and room air conditioners published on April 21, 2011 (''April 2011 final rule''), DOE established separate product classes for vented and vent-less clothes dryers because of the unique utility they offer consumers (*i.e.,* the ability to be installed in space-constrained locations, such as high-rise apartments and recreational vehicles, where venting dryers would be precluded entirely due to venting restrictions). 76 FR 22454, 22485. In the April 2011 final rule, ventless dryers provided that subset of consumers the utility of being able to dry their clothes at all, so it is not simply a matter of additional installation cost, as confronts us in this rulemaking for CWH equipment. *Id.* Consequently, DOE believes that such a distinction would not apply to commercial gas-fired water heaters, because all gas-fired water heaters require venting and all installations could accommodate a condensing gas water heater.

DOE reiterates that disparate equipment may have very different consumer utilities, thereby making direct comparisons difficult and potentially misleading. For instance, in the April 2011 final rule, DOE established separate product classes for vented and ventless clothes dryers because of their unique utility to consumers, as previously discussed. But in a final rule for energy conservation standards for residential water heaters, pool heaters, and direct heating equipment published on April 16, 2010, DOE determined that water heaters that utilize heat pump technology did not need to be put in a separate product class from conventional types of hot water heaters that utilize electric resistance technology, even though water heaters utilizing heat pumps require the additional installation of a condensate drain that a hot water heater utilizing electric resistance technology does not require. 75 FR 20112, 20134–20135. DOE found that regardless of these installation factors, the heat pump water heater and the conventional water heater still had the same utility to the consumer: Providing hot water. *Id.* In both cases, DOE made its finding based on consumer type and utility type, rather than product design criteria that impact product efficiency or installation costs. These distinctions in both the consumer type and the utility type are important because, as DOE has previously pointed out, taken to the extreme, each different design could be designated a different ''product class'' and, therefore, require different energy conservation standards.

Tying the concept of ''feature'' to a specific technology would effectively lock-in the currently existing technology as the ceiling for product efficiency and eliminate DOE's ability to address technological advances that could yield significant consumer benefits in the form of lower energy costs while providing the same functionality for the consumer. DOE is very concerned that determining features solely on product technology could undermine the Department's Appliance Standards Program. If DOE is required to maintain separate product classes to preserve less-efficient technologies, future advancements in the energy efficiency of covered products would become largely voluntary, an outcome which seems inimical to Congress's purposes and goals in enacting EPCA.

DOE tentatively concludes that both non-condensing and condensing commercial gas-fired CWH equipment provide the same hot water for use by commercial consumers. Furthermore, DOE has tentatively concluded that condensing gas-fired water heaters could replace non-condensing gas-fired water heaters in all commercial settings, although in certain instances this may lead to significant installation costs. DOE recognizes the potential increased installation costs that a proposed condensing standard might impose on some subset of consumers, and has factored such installation costs in its LCC analysis. However, the possibility that installing a non-condensing commercial water heater may be less costly than a condensing commercial water heater because of the difference in venting methods does not justify separating the two kinds of equipment. Condensing technology is discussed in more detail in the screening analysis at section IV.B, and installation costs for all equipment classes are discussed in more detail in section IV.F.2.b of this NOPR and in chapter 8 of the NOPR TSD.

Issue 8: DOE seeks comment on its proposed equipment class structure, and whether any equipment classes are unnecessary or additional equipment classes are needed.

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 Web sites, the AHRI Directory of Certified Product Performance,[34] the California Energy Commission (CEC) Appliance Efficiency Database,[35] and DOE's Compliance Certification Database.[36] 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: 269 commercial gas-fired storage water heaters, 67 residential-duty commercial gas-fired storage water heaters, 71 electric storage water heaters, 59 commercial gas-fired storage-type instantaneous water heaters (storage water heaters with greater than 4,000 Btu/h per gallon of stored water), 25 gas-fired tankless water heaters, 239 gas-fired hot water supply boilers, 15 commercial oil-fired storage water heaters, 5 residential-duty commercial oil-fired storage water heaters, and 4 commercial oil-fired storage-type instantaneous water heaters. No oil-fired instantaneous water heaters or hot water supply boilers were found on the market. As the database was compiled mostly from certification databases, efficiency data—standby loss and thermal efficiency for storage water heaters, thermal efficiency for instantaneous water heaters and hot water supply boilers—were available for all models considered. 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 the manufacturers could use to improve energy efficiency for CWH equipment. This effort produces an initial list of all the technologies that DOE believes 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.

In the October 2014 RFI, DOE listed twelve technology options and requested comment regarding their applicability to the current market and their impact on energy efficiency of CWH equipment. 79 FR 62899, 62904 (Oct. 21, 2014). The technology options identified in the October 2014 RFI were as follows:

- Heat traps
- Improved insulation (including increasing jacket insulation, insulating tank bottom, or using a plastic tank (electric only), advanced insulation types, foam insulation, and pipe and fitting insulation)
- Power and direct venting
- Fully condensing technology (including storage, instantaneous, and hybrid, as well as pulse combustion)
- Improved flue design (including high-efficiency flue baffles, multiple flues, submerged combustion chamber, and optimized flue geometry)
- Sidearm heating and two-phase thermosiphon technology
- Electronic ignition systems
- Improved heat pump water heaters
- Thermovoltaic and thermoelectric generators
- Improved controls (including timer controls, modulating controls, and intelligent and wireless controls and communication)
- Self-cleaning

[34] Based on listings in the AHRI Directory last accessed in September, 2014. (Available at: *https://www.ahridirectory.org/ahridirectory/pages/home.aspx*). Standby loss data for electric storage water heaters were updated on March 17, 2015. Details of the data comprising the database used for analysis are described in Chapter 3 of the NOPR TSD.

[35] Available at *http://www.appliances.energy.ca.gov/AdvancedSearch.aspx*.

[36] Available at *https://www.regulations.doe.gov/certification-data/*

- Improved burners (including variable firing-rate burners, low-stage firing burners, and modulating burners)

Id.

DOE also solicited information on potential additional energy-efficiency-improving technology options that DOE should consider for the purposes of this rulemaking in the October 2014 RFI. 79 FR 62899, 62904 (Oct. 21, 2014). Several parties commented on the list of technologies. A.O. Smith, Bradford White, Rheem, and AHRI all commented that self-cleaning should not be included in the list because it is a feature that improves maintenance of storage water heaters, not efficiency. (A.O. Smith, No. 2 at p. 2; Bradford White, No. 3 at p. 2; Rheem, No. 10 at p. 1; AHRI, No. 5 at p. 2) Bradford White, Rheem, and AHRI also commented that heat traps should not be included because heat traps are installed in external piping for commercial water heater installations. (Bradford White, No. 3 at p. 2; Rheem, No. 10 at p. 1; AHRI, No. 5 at p. 2) AHRI added that ASHRAE Standard 90.1 requires inclusion of heat traps for CWH equipment when installed, not when manufactured. (AHRI, No. 5 at p. 2) A. O. Smith also stated that fully condensing technology should not be considered for oil-fired units, as it is not feasible to develop given the size of the market. (A.O. Smith, No. 2 at p. 2)

DOE agrees with the commenters that self-cleaning technology would not affect the thermal efficiency or standby loss of a storage water heater. DOE also agrees that heat traps are most commonly installed in piping, not in CWH equipment. Section 7.4.6 of ASHRAE Standard 90.1–2013 requires heat traps be installed either integral to the water heater or storage tank, or in both the inlet and outlet piping as close as possible to the storage tank, if not part of a recirculating system.[37] DOE was not able to find evidence of a significant number of models of CWH equipment on the market with installed heat traps. Therefore, for the reasons above, DOE has removed these two technologies from the list of potential technology options considered. Regarding condensing technology for oil-fired water heaters, DOE did not analyze oil-fired water heaters in this rulemaking, as discussed previously in section III.C of this document. However, condensing technology was analyzed as a technology option for gas-fired CWH equipment.

Steffes recommended that grid-interactive technology for electric storage water heaters be added to the list of technologies, as they achieve significant system efficiency improvements and carbon reductions. (Steffes, No. 6 at p. 2) Because the efficiency examined in this rulemaking is that of CWH equipment at the point of manufacture as measured by the DOE test procedure, and not of the entire energy grid, DOE has tentatively concluded that grid-interactive technology would not improve the efficiency of CWH equipment as measured by its test procedure.

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

- Plastic tank
- Direct vent
- Timer controls
- Intelligent and wireless controls
- Modulating combustion (for storage water heaters; including modulating controls and variable firing-rate burners, low-stage firing burners, and modulating burners)[38]
- Self-cleaning

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

After considering the comments above, DOE below lists all of the technology options considered for improving the energy efficiency of CWH equipment as part of this NOPR. This list includes those options identified in the October 2014 RFI (discussed previously), with the exception of those subsequently determined not to improve energy efficiency. In addition, DOE has identified electromechanical flue dampers as a technology option that can increase the efficiency of water heaters. DOE also included three separate technology options often used in condensing CWH equipment: (1) Mechanical draft; (2) condensing heat exchangers, and (3) premix burners. DOE did not consider CO_2 heat pump water heaters for analysis because, as explained in section III.C, commercial electric heat pump water heaters were not analyzed for this NOPR. The technology options selected are discussed in further detail in Chapter 3 of the NOPR TSD. In summary, DOE has identified and considered in this NOPR the following potential technologies for improving the energy efficiency of CWH equipment:

- 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)
- Thermovoltaic and thermoelectric generators
- Premix burner (including submerged combustion chamber for gas-fired storage water heaters and storage-type instantaneous water heaters)
- Electromechanical flue damper.

B. Screening Analysis

DOE uses the following four screening criteria to determine which technology

[37] ASHRAE, Standard 90.1–2013 (Available at *www.ashrae.org*).

[38] DOE considers modulating combustion to be a baseline design feature for gas-fired tankless water heaters.

options are suitable for further consideration in an energy conservation standards rulemaking:

1. *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.

2. *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.

3. *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 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.

4. *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.

10 CFR part 430, subpart C, appendix A, 4(a)(4) and 5(b).

These four screening criteria do not include the proprietary status of design options. As noted previously in section III.D.1, DOE only considers efficiency levels achieved through the use of proprietary designs in the engineering analysis if they are not part of a unique path to achieve that efficiency level. DOE's research has not shown any of the technologies identified in the technology assessment to be proprietary, and thus, DOE did not eliminate any technologies for that reason.

Issue 9: DOE seeks comment on its tentative conclusion that none of the identified technology options are proprietary, and if any technologies are proprietary, requests additional information regarding proprietary designs and patented technologies.

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
Advanced insulation types	All storage water heaters	X	X		
Condensing pulse combustion	All gas-fired equipment classes	X	X		
Sidearm heating	All gas-fired storage	X	X		
Two-phase thermosiphon technology.	All gas-fired storage		X		
Gas absorption heat pump water heaters.	Gas-fired instantaneous water heaters.		X		
Thermovoltaic and thermoelectric generators.	All gas-fired equipment classes	X	X		

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

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 class	Improved insulation (thickness, tank bottom, foam)	Mechanical draft	Condensing heat exchanger	Increased heat exchanger area, baffling	Electronic ignition	Premix burner	Electro-mechanical flue damper
Electric storage water heaters	X						
Commercial gas-fired storage water heaters and storage-type instantaneous water heaters	X	X	X	X		X	
Residential-duty gas-fired storage water heaters	X	X	X	X	X	X	X

TABLE IV.4—TECHNOLOGY OPTIONS CONSIDERED FOR ENGINEERING ANALYSIS—Continued

Equipment class	Improved insulation (thickness, tank bottom, foam)	Mechanical draft	Condensing heat exchanger	Increased heat exchanger area, baffling	Electronic ignition	Premix burner	Electro-mechanical flue damper
Gas-fired instantaneous water heaters and hot water supply boilers		X	X	X		X	

C. Engineering Analysis

The engineering analysis establishes the relationship between an increase in energy efficiency of the equipment and the increase in manufacturer selling price (MSP) associated with that efficiency level. This relationship serves as the basis for the cost-benefit calculations for commercial consumers, manufacturers, and the Nation. In determining the cost-efficiency relationship, DOE estimates the increase in manufacturer cost associated with increasing the efficiency of equipment above the baseline up to the maximum technologically feasible (''max-tech'') efficiency level for each equipment class.

1. Methodology

DOE typically structures its engineering analysis using one of three approaches: (1) Design-option; (2) efficiency-level; or (3) reverse engineering (or cost-assessment). A design-option approach identifies individual technology options (from the market and technology assessment) that can be used alone or in combination with other technology options to increase the energy efficiency of a baseline unit of equipment. Under this approach, cost estimates of the baseline equipment and more-efficient equipment that incorporates design options are modeled based on manufacturer or component supplier data or engineering computer simulation models. Individual design options, or combinations of design options, are added to the baseline model in descending order of cost-effectiveness. An efficiency-level approach establishes the relationship between manufacturer cost and increased efficiency at predetermined efficiency levels above the baseline. Under this approach, DOE typically assesses increases in manufacturer cost for incremental increases in efficiency, rather than the technology or design options that would be used to achieve such increases. The efficiency level approach uses estimates of cost and efficiency at distinct levels of efficiency from publicly-available information, and information gathered in manufacturer interviews that is supplemented and verified through technology reviews. A reverse-engineering, or cost-assessment, approach involves disassembling representative units of CWH equipment, and estimating the manufacturing costs based on a ''bottom-up'' manufacturing cost assessment; such assessments use detailed data to estimate the costs for parts and materials, labor, shipping/packaging, and investment for models that operate at particular efficiency levels. The reverse-engineering approach involves testing products for efficiency and determining costs from a detailed bill of materials (BOM) derived from reverse engineering representative equipment.

DOE conducted this engineering analysis for CWH equipment using a combination of the efficiency-level and cost-assessment approaches. For the analysis of thermal efficiency levels for commercial and residential-duty storage and instantaneous water heaters, DOE identified the efficiency levels for the analysis based on market data and then used the cost-assessment approach to determine the manufacturing costs at those levels. For the analysis of standby loss levels for storage water heaters, DOE identified efficiency levels for analysis based on market data and commonly used technology options (*i.e.,* insulation type, thickness), and then used the cost-assessment approach to determine the manufacturing costs of models at those levels.

DOE received several comments from interested parties on the approach to the engineering analysis. A.O. Smith, Bradford White, Rheem, and AHRI all agreed with the use of the reverse-engineering approach, but stated that appropriate cost estimates for components, materials, and labor should be used. (A.O. Smith, No. 2 at p. 2; Bradford White, No. 3 at p. 2; Rheem, No. 10 at p. 2; AHRI, No. 5 at p. 3) DOE notes that it solicited input from manufacturers during manufacturer interviews on the above cost estimates, other relevant engineering assumptions, and other issues regarding this rulemaking. The manufacturer interview process is described in more detail in section IV.J.3 and chapter 12 of the NOPR TSD.

2. Representative Equipment for Analysis

For the engineering analysis, DOE reviewed all CWH equipment classes analyzed in this rulemaking. Because the storage volume and input capacity can affect the energy efficiency of CWH equipment, DOE examined each equipment class separately. Within each equipment class, DOE analyzed the distribution of models available on the market and held discussions with manufacturers to determine appropriate representative equipment for each equipment class.

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. DOE examined specific storage volumes for gas-fired and electric storage water heaters (referred to as representative storage volumes). Because DOE lacked specific information on shipments, DOE examined the number of models at each storage volume listed in the AHRI Directory 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 class.

The current standby loss standards for commercial storage water heaters differ in the storage volume metric used in calculation of the standby loss standard (rated storage volume is used for certain classes, while measured storage volume is used for others). Specifically, the standby loss standard for gas-fired and oil-fired storage water heaters depends on the rated storage volume of the water heater. However, the standby loss standard for electric storage water heaters depends on the measured storage volume of the water heater. DOE notes there is often a difference between the measured and rated volumes of water heaters, as reported in data in the AHRI Directory. Therefore, to calculate standby loss levels for a representative electric storage water heater, a representative measured storage volume is needed. In section III.I of this NOPR, DOE proposes to require that the rated storage volume equal the measured storage volume. Therefore, DOE selected a representative measured storage volume for electric storage water heaters based upon data for measured volumes for units at the selected representative rated storage volume in the AHRI Directory. Table IV.5 shows both selected representative storage volumes for electric storage water heaters.

For all CWH equipment classes, the input capacity is also a significant factor for cost and efficiency. Fossil-fuel-fired water heaters with higher input capacities have higher materials costs, and may also have higher labor and shipping costs. Fossil-fuel-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. Tankless water heaters and hot water supply boilers require larger heat exchangers to transfer more heat with a higher input capacity. Electric storage water heaters with higher input capacities have higher-wattage resistance heating elements, which can increase the cost of purchased parts for the water heater manufacturer. DOE examined input capacities for units in all CWH equipment classes to determine representative input capacities. Because DOE did not receive any shipments data for specific input capacities, DOE considered the number of models at each input capacity in the database of models it compiled (based on the AHRI Directory, CEC Appliance Database, and manufacturer literature) as well as feedback from manufacturer interviews. DOE used this information to select representative input capacities for each equipment class, which are shown in Table IV.5.

TABLE IV.5—REPRESENTATIVE STORAGE VOLUMES AND INPUT CAPACITIES

Equipment class	Specifications	Representative storage volume (gal) *	Representative input capacity (kBtu/h or kW)
Electric storage water heaters	N/A	119 (rated), 114 (measured).	18 kW.
Commercial gas-fired storage water heaters and gas-fired storage-type instantaneous water heaters.	>105 kBtu/h or >120 gal	100	199 kBtu/h.
Residential-duty gas-fired storage water heaters **	≤105 kBtu/h and ≤120 gal	75	76 kBtu/h.
Gas-fired instantaneous water heaters and hot water supply boilers:			
Tankless water heaters	<10 gal		250 kBtu/h.
Hot water supply boilers	All †		399 kBtu/h

* For all equipment classes where not specified, the representative volume is a rated storage volume, not a measured storage volume.

** 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, hot water supply boilers <10 gallons and ≥10 gallons were analyzed in the same equipment class. Amended standby loss standards for hot water supply boilers ≥10 gallons were not analyzed in this NOPR, as discussed in section III.C.8. Therefore, no representative storage volume was chosen for instantaneous water heaters or hot water supply boilers.

Issue 10: DOE seeks comment on the representative CWH equipment used in the engineering analysis.

3. Efficiency Levels for Analysis

For each equipment class, 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 maximum technologically feasible (''max-tech'') efficiency level for each equipment class. DOE conducted a survey of its CWH equipment database and manufacturers' Web sites to determine the highest thermal efficiency levels on the market for each equipment class. DOE identified the most stringent standby loss level for each class by consideration of rated standby loss values of units currently on the market as well as technology options that DOE believes to be feasible but may not currently be included in units on the market in each equipment class. Thermal efficiency levels were analyzed for all CWH equipment considered in this rulemaking except for electric storage water heaters. Standby loss levels were analyzed for all commercial and residential-duty storage water heaters and storage-type instantaneous water heaters.

a. Baseline Efficiency Levels

Baseline equipment is used as a reference point for each equipment class in the engineering analysis and the life-cycle cost and payback-period 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. 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 analysis for each equipment class are presented in Table IV.6.

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

Equipment class	Thermal efficiency (%)
Electric storage water heaters	....
Commercial gas-fired storage water heaters and gas-fired storage-type instantaneous water heaters	80
Residential-duty gas-fired storage water heaters	80
Gas-fired instantaneous water heaters and hot water supply boilers:	
Tankless water heaters	80
Hot water supply boilers	80

DOE used the current energy conservation standards for standby loss to set the baseline standby loss levels. Table IV.7 shows these baseline standby loss levels for representative equipment for each equipment class.

TABLE IV.7—BASELINE STANDBY LOSS LEVELS FOR REPRESENTATIVE CWH EQUIPMENT

Equipment class	Representative storage volume (gal) *	Representative input capacity (kBtu/h or kW)	Baseline standby loss level (Btu/h)
Electric storage water heaters	119 (rated), 114 (measured)	18 kW	353
Commercial gas-fired storage water heaters and gas-fired storage-type instantaneous water heaters.	100	199 kBtu/h	1349
Residential-duty gas-fired storage water heaters	75	76 kBtu/h	1048
Gas-fired instantaneous water heaters and hot water supply boilers:			
Tankless water heaters	....	250 kBtu/h	....
Hot water supply boilers	....	399 kBtu/h	....

* For all equipment classes where not specified, the representative volume is a rated storage volume, not a measured storage volume.

In the October 2014 RFI, DOE sought comment on approaches to consider when establishing baseline efficiency levels for equipment classes transitioning to the UEF metric. 79 FR 62899, 62905 (Oct. 21, 2014). A.O. Smith, Bradford White, Rheem, and AHRI commented that DOE should convert the current thermal efficiency and standby loss standards to UEF to use as the baseline levels. (A.O. Smith, No. 2 at p. 2; Bradford White, No. 3 at p. 2; Rheem, No. 10 at p. 1; AHRI, No. 5 at p. 3) DOE has conducted an analysis for residential-duty water heaters using thermal efficiency and standby loss. Because UEF rating data were not available when this analysis was conducted, DOE is using the mathematical conversion factors proposed in the April 2015 NOPR to translate the results of the analyzed thermal efficiency and standby loss levels to UEF levels. 80 FR 20116, 20143 (April 14, 2015). This conversion of the existing standards to UEF is described in more detail in section IV.C.9. Therefore, the current thermal efficiency and standby loss standards were used as baseline levels.

b. Intermediate and Max-Tech Efficiency Levels

For each equipment class, DOE analyzes several efficiency levels and determines the manufacturing cost at each of these levels. For this NOPR, DOE developed efficiency levels based on a review of available equipment. As noted previously, DOE compiled a database of CWH equipment to determine what types of equipment are currently available to commercial consumers. For each representative equipment type, DOE surveyed various manufacturers' equipment offerings to identify the commonly available efficiency levels. By identifying the most prevalent energy efficiency levels in the range of available equipment and examining models at these levels, DOE can establish a technology path that manufacturers would typically use to increase the thermal efficiency of CWH equipment.

DOE established intermediate thermal efficiency levels for each equipment class. 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, DOE chose four thermal efficiency levels between the baseline and max-tech levels for analysis. For residential-duty gas-fired storage water heaters, DOE chose three thermal efficiency levels between the baseline and max-tech levels for analysis. 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 also selected the highest thermal efficiency level identified on the market for each equipment class (*i.e.,* the ''max-tech'' level). The selected thermal efficiency levels are shown in Table IV.8.

TABLE IV.8—BASELINE, INTERMEDIATE, AND MAX-TECH THERMAL EFFICIENCY LEVELS FOR REPRESENTATIVE CWH EQUIPMENT

Equipment class	Thermal efficiency levels					
	Baseline—E_t EL0 (%)	E_t EL1 (%)	E_t EL2 (%)	E_t EL3 (%)	E_t EL4 * (%)	E_t EL5 ** (%)
Electric storage water heaters	-	-	-	-	-	-
Commercial gas-fired storage water heaters and gas-fired storage-type instantaneous water heaters	80	82	90	92	95	99
Residential-duty gas-fired storage water heaters	80	82	90	95	97	-
Gas-fired instantaneous water heaters and hot water supply boilers:						
Tankless water heaters	80	82	84	92	94	96
Hot water supply boilers	80	82	84	92	94	96

* E_t EL4 is the max-tech efficiency level for residential-duty gas-fired storage water heaters.
** 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.

In response to the October 2014 RFI, A. O. Smith stated that max-tech efficiency levels should be condensing for gas-fired storage water heaters, heat pump for electric storage water heaters, and ''near condensing'' for oil-fired storage water heaters. (A. O. Smith, No. 2 at p. 2) Bradford White stated that the max-tech efficiency levels are condensing for gas-fired storage water heaters and heat pump for electric storage water heaters (Bradford White, No. 3 at p. 2) Rheem responded that max-tech efficiency levels within Rheem products are 98 percent thermal efficiency and 325 Btu/h standby loss for electric storage water heaters, 97 percent thermal efficiency and 960 Btu/h for gas-fired storage water heaters, and 94 percent thermal efficiency for gas-fired instantaneous water heaters. (Rheem, No. 10 at p. 3) AHRI commented that max-tech efficiency levels should be determined for each equipment class individually, as condensing would not be an achievable max-tech level for oil-fired storage water heaters. (AHRI, No. 5 at p. 3)

DOE notes that the analyzed max-tech level for commercial gas-fired storage water heaters is condensing as suggested by A. O. Smith and Bradford White. DOE did not consider commercial integrated heat pump water heaters as the max-tech for electric storage water heaters because DOE did not identify any such units on the market. DOE selected higher max-tech thermal efficiency levels than suggested by Rheem, because DOE identified equipment for sale at even higher thermal efficiency levels, which does not appear to make use of any proprietary technology. Given the commercial availability of designs at higher thermal efficiency levels than suggested by Rheem as max-tech, DOE has tentatively concluded that such efficiency levels should be included in the engineering analysis. In response to AHRI, DOE notes that it established max-tech efficiency levels separately for each equipment class, only considering the highest efficiency level on the market within each equipment class. DOE also notes that it did not consider amended energy conservation standards for oil-fired storage water heaters in this NOPR; therefore, these units were not included in the engineering analysis.

EEI commented that DOE should adopt the amended efficiency levels in ASHRAE Standard 90.1–2013 for all CWH equipment classes, arguing this would prevent confusion in the marketplace and allow for earlier compliance dates than if higher standards are proposed. (EEI, No. 8 at p. 2) In response, DOE notes that ASHRAE Standard 90.1–2013 only raised efficiency standards for commercial oil-fired storage water heaters, but DOE also has an independent statutory obligation to review standards for the other CWH equipment classes. In the July 2015 ASHRAE equipment final rule, DOE determined that a thermal efficiency level for oil-fired storage water heaters more stringent than that adopted in ASHRAE Standard 90.1–2013 would not be economically justified and technologically feasible according to the seven criteria outlined in section II.A. 80 FR 42614 (July 17, 2015). Therefore, DOE adopted the amended thermal efficiency level from ASHRAE Standard 90.1–2013 for commercial oil-fired storage water heaters with a compliance date of October 9, 2015, as required by the statute. *Id.* Thus, any proposed increased standards in this rulemaking will not affect the compliance date for the amended standard adopted from ASHRAE Standard 90.1–2013. Because DOE is not considering higher thermal efficiency standards for commercial oil-fired storage water heaters in this rulemaking and given DOE's history of amending energy conservation standards for ASHRAE Standard 90.1 equipment, DOE does not believe proposed increased standards in this rulemaking will lead to confusion in the marketplace.

Joint Advocates commented that the max-tech efficiency levels should be identified by examining the most efficient technologies on the global market as opposed to just the U.S. market. (Joint Advocates, No. 7 at p. 3) As an example, Joint Advocates stated that CO_2 heat pump water heaters should be considered as a max-tech technology. As parts of its energy conservation standards rulemaking process, DOE considers equipment and designs sold both in the U.S. market and in the broader global market. However, for each technology identified from the global market, DOE must also consider its applicability and market barriers specifically for the U.S. market, and, thus, availability in other non-U.S. markets does not necessarily mean a technology will be technologically feasible in the domestic market. DOE considers technologies and their applicability to the U.S. markets in the rulemaking analyses. With regard to the specific recommendation to consider CO_2 heat pump water heaters, as discussed in section III.C.6, DOE notes that it does not currently have a test procedure for commercial heat pump water heaters (including CO_2 heat pump water heaters), and plans to consider energy conservation standards for commercial heat pump water heaters in a future rulemaking.

DOE established intermediate and max-tech standby loss efficiency levels for each equipment class of storage water heaters. Standby loss is a function of rated volume for gas-fired storage water heaters; however, in section III.I of this NOPR, DOE proposes changes to its certification, compliance, and enforcement regulations that would require the rated volume to be based on the mean of the measured volumes in the sample. DOE believes that to be compliant with these proposed changes, most manufacturers with units having a rated storage volume that does not equal the measured volume will re-rate the storage volumes of their current models based on the measured volumes, as opposed to changing their designs so that the measured storage volume increases to the current rated volume. Therefore, in analyzing market standby loss data for this NOPR, DOE accounted for this change by calculating the maximum standby loss levels under consideration using the measured volume as reported in the AHRI Directory for each model.

Standby loss is a function of storage volume (and input 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. DOE was not able to find any CWH equipment literature that reported standby loss, and, therefore, relied on data obtained from the AHRI Directory. However, there is significant variation in reported standby loss values in the AHRI Directory—*i.e.,* standby loss values for power-vented non-condensing residential-duty gas-fired storage water heaters range from 48 percent to 102 percent [39] of the current standby loss standard. Also, 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. Therefore, DOE analyzed technology options commonly used on the market to help guide its selection of standby loss levels.

One possible source of variation in reported standby loss values is variation in unreported technology options, as previously discussed. Additionally, during manufacturer interviews, manufacturers explained that the current standby loss test procedure leads to significant variation in test results from lab to lab, and sometimes even within the same lab. Several reasons given for this variation include the air draft in the area around the water heater, the wide tolerance for ambient temperature, lack of humidity specification, and variation in venting and insulation of connections. DOE addressed some of these sources of variation in the revised standby loss test procedure for commercial water heaters proposed in the 2016 CWH TP NOPR. (See EERE–2014–BT–TP–0008)

DOE developed its incremental and max-tech standby loss levels by considering levels currently on the market, designs detailed in publicly-available equipment literature, observations from equipment teardowns, and feedback from manufacturer interviews. For commercial gas-fired storage water heaters, DOE determined that the current minimum Federal standard can be met with installation of 1 inch of fiberglass insulation around the walls of the tank. Therefore, DOE considered 1 inch of fiberglass insulation to correspond to the baseline standby loss efficiency level. DOE then considered the next incremental standby loss level to correspond to the use of sprayed polyurethane foam insulation instead of fiberglass insulation. From a survey of units on the market, DOE considers switching from 1 inch of fiberglass insulation to 1 inch of foam insulation a more commonly used pathway to decrease standby loss than using 2 inches of fiberglass insulation. From equipment teardowns 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, SL EL2, to correspond to 2 inches of polyurethane foam. While more-stringent standby loss levels than SL EL2 exist on the market, these more-stringent values are only rated for condensing units with specific heat exchanger designs. Because DOE does not wish to mandate specific heat exchanger designs for achieving condensing thermal efficiency levels, standby loss levels more stringent than SL EL2 were not analyzed. Therefore, DOE considered SL EL2 as the max-tech standby loss level for commercial gas-fired storage water heaters. Table IV.9 shows the technology options identified for each standby loss level for commercial gas-fired storage water heaters.

Based on a review of available equipment on the market and feedback from manufacturers, DOE analyzed all non-condensing commercial gas-fired storage water heaters (*i.e.,* water heaters rated at thermal efficiency levels between 80 percent and 82 percent) as including electromechanical flue dampers. Electromechanical flue dampers were only included in the analysis for non-condensing commercial gas-fired storage water heaters, because flue dampers are not used with mechanical draft systems, which are required for condensing units. In place of standby loss reduction from electromechanical flue dampers, DOE included standby loss reduction from mechanical draft systems for all condensing commercial gas-fired storage water heaters in its calculated standby loss levels. Therefore, for commercial gas-fired storage water heaters, 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.

TABLE IV.9—TECHNOLOGY OPTIONS IDENTIFIED AT EACH STANDBY LOSS EFFICIENCY LEVEL FOR COMMERCIAL GAS-FIRED STORAGE WATER HEATERS

Standby loss level	Technology Options
SL EL0—Baseline	1″ fiberglass insulation.
SL EL1	1″ foam insulation.
SL EL2	2″ foam insulation.

For residential-duty gas-fired storage water heaters, DOE has tentatively concluded that the current Federal standard may be met through use of 1 inch of polyurethane foam insulation. From surveying commercially-available equipment, DOE notes that all baseline residential-duty gas-fired storage water heaters have a standing pilot and do not use flue dampers. Therefore, in addition to increasing the thickness of foam insulation, DOE also considered electromechanical flue dampers and electronic ignition as technology options for reducing standby loss. 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. Therefore, for residential-duty gas-fired storage water heaters, DOE considered electromechanical flue dampers to be a technology option not featured in baseline non-condensing equipment, and considered mechanical draft systems to be featured in all condensing equipment. Similarly to commercial gas-fired storage water

[39] Because DOE calculated the maximum standby loss using measured storage volume instead of the rated storage volume, some units at or near the maximum allowable standby loss level have a standby loss level that exceeds the current standard when calculated using the measured volume.

heaters, both of these technologies act to reduce standby losses out the flue.

For condensing residential-duty gas-fired storage water heaters, rated standby loss market data show that the most-efficient standby levels are only achieved by models with particular condensing heat exchanger designs. Specifically, DOE observed that the most-efficient standby loss level on the market is only achieved by a model with 90-percent thermal efficiency. It is not evident that this standby level can be reached by heat exchanger designs that also yield more-efficient condensing thermal efficiency levels. DOE chose not to analyze standby loss levels that have not been demonstrated to be achievable with more-efficient thermal efficiency level designs, because thermal efficiency typically will have a greater impact on the energy use of CWH equipment than standby loss. To ensure the continued availability of condensing CWH equipment with thermal efficiencies above 90 percent, DOE has considered an amended standby loss level that is reduced to 48 percent of the current standby loss standard as the max-tech standby loss level. DOE's market assessment shows that this standby loss level can be achieved by all condensing residential-duty gas-fired storage water heaters currently on the market. To inform the selection of SL EL0 for condensing residential-duty gas-fired storage water heaters, DOE considered the increase in standby loss that would occur from reducing the thickness of polyurethane foam insulation from 2 inches to 1 inch. Table IV.10 shows the technology options corresponding to each standby loss level selected for residential-duty gas-fired storage water heaters. As previously discussed, electromechanical flue dampers were only considered as a technology option for non-condensing equipment; therefore, SL EL2 and SL EL3 were only analyzed for non-condensing residential-duty gas-fired storage water heaters.

TABLE IV.10—TECHNOLOGY OPTIONS IDENTIFIED AT EACH STANDBY LOSS EFFICIENCY LEVEL FOR RESIDENTIAL-DUTY GAS-FIRED STORAGE WATER HEATERS

Standby loss level	Technology options
SL EL0—Baseline	1″ foam insulation, standing pilot.
SL EL1	2″ foam insulation, electronic ignition.
SL EL2	1″ foam insulation, electronic ignition, electromechanical flue damper.
SL EL3	2″ foam insulation, electronic ignition, electromechanical flue damper.

For electric storage water heaters, DOE determined that the current Federal standard may 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, corresponds to 3 inches of polyurethane foam insulation. Table IV.11 shows the standby loss levels and technology options identified at each level for electric storage water heaters.

TABLE IV.11—TECHNOLOGY OPTIONS IDENTIFIED AT EACH STANDBY LOSS EFFICIENCY LEVEL FOR ELECTRIC STORAGE WATER HEATERS

Standby loss level	Technology options
SL EL0—Baseline	2″ foam insulation.
SL EL1	3″ foam insulation.

To inform the selection of standby loss levels, DOE performed heat loss calculations for representative equipment for each equipment class. These calculations yielded more stringent standby loss levels corresponding to the identified technology options. Chapter 5 of the NOPR TSD provides details on these heat loss calculations. Standby loss levels are shown in Table IV.12, Table IV.13, and Table IV.14 in terms of Btu/h for the representative equipment. However, to modify the current Federal standard, 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.8.

For commercial and residential-duty gas-fired storage water heaters, standby loss is measured predominantly as a function of fuel flow 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. For a given standby loss level (*i.e.,* SL EL0, SL EL1, or SL EL2), DOE scaled down (*i.e.,* made more stringent) the portion of the standby loss attributable to fuel consumption as thermal efficiency increased. 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 previously discussed, the most stringent standby loss level examined was a level that can be achieved by all condensing residential-duty gas-fired storage water heaters currently on the market. Because the examined level is currently met by all equipment at condensing thermal efficiency levels, DOE did not lower the stringency of the standby loss level for lower condensing thermal efficiency levels. Table IV.12, Table IV.13, and Table IV.14 show the examined standby loss levels for commercial gas-fired storage water heaters, residential-duty gas-fired storage water heaters, and electric storage water heaters, respectively.

TABLE IV.12—STANDBY LOSS LEVELS FOR COMMERCIAL GAS-FIRED STORAGE WATER HEATERS, 100 GALLON RATED STORAGE VOLUME, 199,000 Btu/h INPUT CAPACITY

Thermal efficiency level	Thermal efficiency (%)	Standby loss (Btu/h)		
		SL EL0	SL EL1	SL EL2
E_t EL0	80	1349	1148	993
E_t EL1	82	1316	1120	969
E_t EL2	90	1225	1043	902
E_t EL3	92	1199	1021	883
E_t EL4	95	1163	989	856
E_t EL5	99	1117	951	823

TABLE IV.13—STANDBY LOSS LEVELS FOR RESIDENTIAL-DUTY GAS-FIRED STORAGE WATER HEATERS, 75 GALLON RATED STORAGE VOLUME, 76,000 Btu/h INPUT CAPACITY

Thermal efficiency level	Thermal efficiency (%)	Standby loss (Btu/h)			
		SL EL0	SL EL1	SL EL2 *	SL EL3 *
E_t EL0	80	1048	836	811	707
E_t EL1	82	1022	816	791	690
E_t EL2	90	624	503		
E_t EL3	95	624	503		
E_t EL4	97	624	503		

* Electromechanical flue dampers were not considered as a technology option for condensing water heaters because flue dampers are not used with mechanical draft systems.

TABLE IV.14—STANDBY LOSS LEVELS FOR ELECTRIC STORAGE WATER HEATERS, 114 GALLON MEASURED STORAGE VOLUME

Thermal efficiency	Standby loss (Btu/h)	Standby loss (%/h)		
		SL EL0	SL EL1	SL EL0
98%	353	298	0.54	0.45

DOE notes that because of its use of heat loss calculations corresponding to commonly used technology options to inform the selection of standby loss levels in addition to rated standby loss market data, the most stringent analyzed standby loss levels do not necessarily reflect the current market max-tech level for each equipment class. For some equipment thermal efficiency levels, the most stringent analyzed standby loss level may be less efficient than that of the most efficient unit on the market, and for other levels, it may be more efficient. While there may not be units on the market with a rated standby loss as efficient as some of the examined standby loss levels, DOE has determined these levels would be achievable through various technology options, including, but not limited to, those DOE examined for this analysis. Chapter 5 of the NOPR TSD includes a discussion of the following technology options with the potential to reduce standby loss that DOE did not consider for this analysis and the reasons for their exclusion: (1) Changing tank aspect ratio; (2) improved insulation on tank top and bottom; (3) greater coverage of foam insulation; and (4) improved baffling. DOE did not include standby loss reduction from baffling because of insufficient data for estimating the reduction, and therefore, DOE requests input on this matter as well as DOE's estimated standby loss reduction for electromechanical flue dampers and mechanical draft.

Issue 11: DOE seeks comment on all efficiency levels analyzed for CWH equipment, including thermal efficiency and standby loss levels. In particular, DOE is interested in the feasibility of the max-tech thermal efficiency levels and standby loss levels, including whether these efficiency levels can be achieved using the technologies screened-in during the screening analysis (see section IV.B), and whether higher efficiencies are achievable using technologies that were screened-in during the screening analysis. DOE is also interested in the feasibility of achieving the analyzed standby loss levels using the identified technology options.

Issue 12: DOE seeks input on the reduction in standby loss of gas-fired storage water heaters from the technology options for which DOE estimated standby loss levels (*i.e.,* varying insulation type and thickness, electromechanical flue dampers, and mechanical draft) and the technology options for which DOE did not have sufficient data to develop an estimate (including baffling).

4. Teardown Analysis

After selecting a representative input capacity and representative storage volume (for storage water heaters) for each equipment class, 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. To assemble the BOMs and to calculate the manufacturing product costs (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 a unit of equipment that was physically disassembled and a similar unit of 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 Web sites). 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 used data from 11 physical teardowns and 21 catalog teardowns to inform development of cost estimates for CWH equipment.

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. 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 equipment class 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. 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 can also determine the efficiency levels at which manufacturers tend to make major technological design changes. Table IV.15, Table IV.16, Table IV.17, and Table IV.18 show the major technology options DOE observed and analyzed for each thermal efficiency level and equipment class. Technology options that manufacturers use to reach each standby loss level are discussed in section IV.C.3.b. 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 units currently on the market, as they do not improve efficiency but do add cost to the unit. In other words, DOE assumed the same level of non-efficiency related features and functionality at all efficiency levels.

TABLE IV.15—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.16—TECHNOLOGIES IDENTIFIED AT EACH THERMAL EFFICIENCY LEVEL FOR RESIDENTIAL-DUTY 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, induced draft blower.
E_t EL3	95	Condensing heat exchanger, forced draft blower, premix burner, increased heat exchanger surface area.
E_t EL4	97	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 EL4.

TABLE IV.17—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.18—TECHNOLOGIES IDENTIFIED AT EACH THERMAL EFFICIENCY LEVEL FOR GAS-FIRED 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, inducer 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.

DOE notes from surveying units currently on the market 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.

5. Manufacturing Production Costs

After calculating the cost estimates for all the components in each teardown unit, DOE totaled the cost of materials, labor, depreciation, and direct overhead used to manufacture each type of equipment in order to calculate the manufacturing production cost (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 reported 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 combination of thermal efficiency and standby loss levels considered for representative equipment of each equipment class. Table IV.19, Table IV.20, Table IV.21, and Table IV.22 show the MPC for each efficiency level for each equipment class. DOE 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 uses these production cost percentages in the MIA (see chapter 12 of the NOPR TSD).

TABLE IV.19—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 (%)	Standby loss efficiency level		
		SL EL0	SL EL1	SL EL2
E_t EL0	80	$1,023.59	$1,029.70	$1,051.20
E_t EL1	82	1,046.14	1,052.31	1,074.10
E_t EL2	90	1,253.56	1,259.97	1,282.19
E_t EL3	92	1,263.93	1,270.35	1,292.63
E_t EL4	95	1,288.05	1,294.51	1,316.95
E_t EL5	99	1,331.09	1,335.00	1,360.66

TABLE IV.20—MANUFACTURER PRODUCTION COSTS FOR RESIDENTIAL-DUTY GAS-FIRED STORAGE WATER HEATERS, 75-GALLON RATED STORAGE VOLUME, 76,000 Btu/h INPUT CAPACITY

Thermal efficiency level	Thermal efficiency (%)	Standby loss efficiency level			
		SL EL0	SL EL1	SL EL2	SL EL3
E_t EL0	80	$354.00	$401.35	$441.95	$462.14
E_t EL1	82	359.37	407.06	447.89	468.18
E_t EL2	90	667.75	685.67		
E_t EL3	95	810.33	828.15		
E_t EL4	97	818.60	836.43		

TABLE IV.21—MANUFACTURER PRODUCTION COSTS FOR ELECTRIC STORAGE WATER HEATERS, 114-GALLON MEASURED STORAGE VOLUME

Thermal efficiency	Standby loss efficiency level	
	SL EL0	SL EL1
98%	$854.25	$883.40

TABLE IV.22—MANUFACTURER PRODUCTION COSTS FOR GAS-FIRED INSTANTANEOUS WATER HEATERS AND HOT WATER SUPPLY BOILERS

Thermal efficiency level	Thermal efficiency (%)	Equipment group	
		Gas-fired tankless water heaters	Gas-fired hot water supply boilers
		250,000 Btu/h	399,000 Btu/h
E_t EL0	80	$629.67	$1,182.00
E_t EL1	82	638.62	1,205.56
E_t EL2	84	647.38	1,411.17
E_t EL3	92	790.45	2,671.86
E_t EL4	94	804.87	2,826.90
E_t EL5	96	824.45	2,981.94

6. Manufacturer Markup

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 meet new or amended energy conservation standards, manufacturers often introduce design changes to their equipment lines that result in increased MPCs. Depending on the competitive pressures, some or all of the increased production costs may be passed from manufacturers to retailers and eventually to commercial consumers in the form of higher purchase prices. As production costs increase, manufacturers typically incur additional overhead. The MSP should be high enough to recover the full cost of the equipment (*i.e.,* full production and non-production costs) and yield a profit. The manufacturer markup has an important bearing on profitability. A high markup under a standards scenario suggests manufacturers can readily pass along the increased variable costs and some of the capital and product conversion costs (the one-time expenditure) to commercial consumers. A low markup suggests that manufacturers will not be able to recover as much of the necessary investment in plant and equipment.

To calculate the manufacturer markups, DOE used 10–K reports [40] submitted to the U.S. Securities and Exchange Commission (SEC) by the three publicly-owned companies that manufacture CWH equipment. The financial figures necessary for calculating the manufacturer markup are net sales, costs of sales, and gross profit. DOE averaged the financial figures spanning the years 2008 to 2013 in order to calculate the markups for CWH equipment. DOE acknowledges that there are numerous manufacturers of CWH equipment that are privately-held companies, which do not file SEC 10–K reports. In addition, while the publicly-owned companies file SEC 10–K reports, the financial information summarized may not be exclusively for the CWH portion of their business and can also include financial information from other product sectors, whose margins could be quite different from that of the CWH industry. DOE discussed the manufacturer markup with manufacturers during interviews, and used the feedback to modify the markup calculated through review of SEC 10–K reports. See chapter 5 of the NOPR TSD for more details about the manufacturer markup calculation.

7. 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 because it

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

is a substantial cost incurred by the manufacturer, DOE accounted for shipping costs of CWH equipment separately from other non-production costs that comprise the manufacturer markup. To calculate the MSP for CWH equipment, DOE multiplied the calculated MPC at each efficiency level by the manufacturer markup and added shipping costs for equipment at the given efficiency level.

In this rulemaking, shipping costs for all classes of CWH equipment were determined based on the area of floor space occupied by the unit. Most CWH equipment units are typically too tall to be double-stacked in a vertical fashion, and they cannot be shipped in any other orientation other than vertical. To calculate these shipping costs, DOE calculated the cost per area of a trailer, based on the standard dimensions 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. Next, DOE examined the average sizes of equipment in each equipment class at each efficiency level and determined the number of units that would fit in a trailer. DOE then calculated the market-weighted average shipping cost per unit using the cost per trailer load. For gas-fired tankless water heaters, DOE assumed units could be double-stacked, due to the smaller size and weight of these units. DOE also assumed tankless water heaters would be manufactured overseas, and, therefore, costs of shipping a 40-foot container on both a cargo ship and a truck were included. Chapter 5 of the NOPR TSD contains additional details about DOE's shipping cost assumptions and DOE's shipping cost estimates.

Issue 13: DOE seeks comment on its methodology for manufacturer production cost, manufacturer selling price, and shipping cost estimates for each equipment class and efficiency level.

8. Maximum Standby Loss Equations

As part of the engineering analysis for commercial storage water heaters and residential-duty commercial storage water heaters, DOE reviewed the maximum standby loss equations that define the existing Federal energy conservation standards for gas-fired and electric 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. The larger surface area results in higher heat transfer rates that result in higher jacket losses. As the input capacity increases for gas-fired and oil-fired water heaters, the surface area of flue tubes may increase, thereby providing additional area for heat loss through the flue tubes. The current equations show that for each storage water heater equipment class, the allowable standby loss increases as the rated storage volume increases, and also as the input rating increases for gas-fired and oil-fired water heaters. The current form of the standby loss standard (in Btu/h) for commercial and residential-duty 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).

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

The current form of the standby loss standard (in %/h) for electric storage water heaters is shown below, dependent only on measured storage volume (V_m, gal). DOE notes that standby loss for electric storage water heaters is not dependent on input capacity because there are no flue tubes or heat exchangers, and a higher input capacity is met with technology options that do not significantly affect the standby loss, typically a combination of either more heating elements or higher-power heating elements.

$$S = 0.3 + \frac{27}{V_m}$$

In order to consider amended standby loss standards for CWH equipment, which are in equation form, DOE would need to consider revising the current standards equations. However, in the October 2014 RFI, DOE identified two potential issues with considering amended maximum standby loss standards equations for commercial gas-fired and oil-fired storage water heaters, and requested comment on approaches for amending the equations. 79 FR 62899, 62905 (Oct. 21, 2014). The first potential issue DOE recognized was how to modify the equation given that there is no intercept in the equation. Because the current standard depends on both volume and input without an intercept, it is only possible to change the slopes for each variable when modifying the standard to fit the analyzed efficiency levels. Changing the slopes could be undesirable if shifting the standard up or down (while maintaining the slopes) would better fit the distribution of units outside the representative input and volume. DOE sought feedback on this issue including the proposal of establishing discrete bins for one variable (volume or input), thereby yielding single-variable equations in each bin. The second issue raised in the RFI was that DOE observed that standby loss is dependent on thermal efficiency (as discussed in section IV.C.3.b of this document) and sought comment on whether thermal efficiency should be taken into account in the standby loss standard. *Id.*

A.O. Smith, Bradford White, Rheem, and AHRI all commented that the structure of the current standby loss standard should not be changed, as it was developed as the result of deliberate, technical discussions. All of these commenters also stated that any changes to the existing structure would bring unnecessary complexity to the analysis, and could require test procedure changes. (A.O. Smith, No. 2 at p. 3; Bradford White, No. 3 at p. 2; Rheem, No. 10 at p. 1; AHRI, No. 5 at p. 3) Joint Advocates suggested that the use of discrete bins would be problematic, due to discontinuities at the bin boundaries. (Joint Advocates, No. 7 at p. 4) Joint Advocates also mentioned allowing the use of rated volume for classification but measured volume for standby loss calculation as an advantage of using continuous equations over bins. Further, Joint Advocates suggested that a standby loss standard should be set that requires some kind of design option that limits flue losses in standby mode. (Joint Advocates, No. 7 at p. 4)

DOE agrees with the commenters that bringing unnecessary complexity to the analysis is not desirable. Therefore, DOE has tentatively decided to consider more-stringent standby loss standards by multiplying the current maximum standby loss equations by reduction factors. The use of reduction factors maintains the structure of the current maximum standby loss equations and does not require the creation of bins or an intercept for altering the equations. This approach does not change the dependence of maximum standby loss on input and rated storage volume or introduce undesirable complexity to the equation, but still allows DOE to consider increased stringency for standby loss energy conservation standards. This reduction factor is the product of two multipliers: one that reduces the standard based upon thermal efficiency, and one that reduces the standard based upon heat loss calculations for standby-loss-reducing technology options identified by DOE (see section IV.C.3.b). The multiplier based upon thermal efficiency uses the ratio of the proposed thermal efficiency level to the current thermal efficiency standard, and takes into account the portion (if any) of standby loss attributable to electric power consumption. The multiplier based upon heat loss calculations uses the ratio of standby loss at each standby loss efficiency level (at the baseline thermal efficiency level) to the current standby loss standard. However, as discussed in section IV.C.3.b, DOE used market standby loss data instead of heat loss calculations and thermal efficiency levels to develop standby loss reduction factors for condensing residential-duty gas-fired storage water heaters. Table IV.23, Table IV.24, and Table IV.25 show the overall standby loss reduction factors for each equipment class and efficiency level. The factors corresponding to the proposed TSL in this NOPR were multiplied by the current standby loss equation to yield the proposed maximum standby loss equations for each equipment class (see section V.C). Chapter 5 of the NOPR TSD includes more detail on the calculation of the standby loss reduction factor and the thermal efficiency-based and heat loss-based multipliers it comprises.

TABLE IV.23—STANDBY LOSS REDUCTION FACTORS FOR COMMERCIAL GAS-FIRED STORAGE WATER HEATERS

Thermal efficiency level	Thermal efficiency (%)	Standby loss reduction factor		
		SL EL0	SL EL1	SL EL2
E_t EL0	80	1.00	0.85	0.74
E_t EL1	82	0.98	0.83	0.72
E_t EL2	90	0.91	0.77	0.67
E_t EL3	92	0.89	0.76	0.65
E_t EL4	95	0.86	0.73	0.63
E_t EL5	99	0.83	0.70	0.61

TABLE IV.24—STANDBY LOSS REDUCTION FACTORS FOR RESIDENTIAL-DUTY GAS-FIRED STORAGE WATER HEATERS

Thermal efficiency level	Thermal efficiency (%)	Standby loss reduction factor			
		SL EL0	SL EL1	SL EL2	SL EL3
E_t EL0	80	1.00	0.80	0.77	0.67
E_t EL1	82	0.98	0.78	0.76	0.66
E_t EL2	90	0.60	0.48		
E_t EL3	95	0.60	0.48		
E_t EL4	97	0.60	0.48		

TABLE IV.25—STANDBY LOSS REDUCTION FACTORS FOR ELECTRIC STORAGE WATER HEATERS

Thermal efficiency	Standby loss reduction factor	
	SL EL0	SL EL1
98%	1.00	0.84

In response to Joint Advocates, DOE notes that although the proposed standby loss equations depend on rated volume, DOE proposes changes in section III.I of this NOPR to its certification, compliance, and enforcement regulations that require that the rated volume must equal the mean of the measured storage volumes of the units in the sample. DOE also notes that it has selected standby loss levels for analysis of non-condensing residential-duty commercial gas-fired storage water heaters that DOE believes would be achieved through the incorporation of electromechanical flue dampers, despite the fact that DOE observed no residential-duty gas-fired storage water heaters with electromechanical flue dampers currently on the market. However, pursuant to EPCA, DOE can establish energy conservation standards that set either a single performance standard or a single design requirement, not both. (42 U.S.C. 6311(18)) Therefore, DOE has not proposed a design requirement for a feature that decreases flue standby losses. After examining the market, DOE has tentatively concluded that all commercial gas-fired storage water heaters on the market currently use electromechanical flue dampers. DOE also notes that a flue damper would not be used with a condensing gas-fired water heater.

Issue 14: DOE seeks comment on its proposed method for modifying the maximum standby loss equations for commercial gas-fired storage water heaters and residential-duty storage water heaters.

9. Conversion of Standards to Uniform Energy Factor

As part of the analysis in this rulemaking, DOE analyzed efficiency levels for residential-duty commercial water heaters in terms of the thermal efficiency and standby loss metrics. However, in the July 2014 final rule, DOE established that residential-duty commercial water heaters would be covered by the new UEF metric. 79 40542, 40586 (July 11, 2014). Further, DOE proposed a method for converting the thermal efficiency and standby loss ratings to UEF using conversion factors in the April 2015 NOPR. 80 FR 20116, 20143 (April 14, 2015). In this NOPR, DOE converted the efficiency levels analyzed for residential-duty commercial gas-fired water heaters from thermal efficiency and standby loss to UEF using the conversion factors proposed in the April 2015 NOPR for residential-duty water heaters for all four draw patterns: High, medium, low, and very small.

For residential-duty commercial storage water heaters, DOE applied each analyzed standby loss level to each unit on the market, calculating the allowed maximum standby loss. The UEF was then calculated for each unit for each draw pattern using this standby loss level and each thermal efficiency level. Because the energy conservation standards for residential-duty commercial water heaters proposed in the April 2015 NOPR were denominated in terms of UEF and had linear equations dependent only on rated volume, in this NOPR DOE developed UEF standard equations for residential-duty gas storage water heaters consistent with this equation format. 80 FR 20116, 20147 (April 14, 2015). However, in section III.I, DOE proposes changes to its certification, compliance, and enforcement regulations that would require the rated volume to be based upon the mean of the measured volumes in a sample. Therefore, the maximum standby loss of units in this analysis to convert efficiency levels to UEF was calculated using the currently reported measured volume instead of the rated volume. A linear regression was performed between the measured volume of each unit and the calculated UEF for each unit, yielding a line of best-fit. Therefore, a line of best-fit was drawn relating UEF to measured volume for each of the four draw patterns. For each line of best-fit, the intercept was then decreased to translate the line down to pass through the point furthest below the line of best-fit (the point with the largest negative residual), creating a minimum line. DOE adopted these minimum lines when establishing the trial standard levels and as the proposed energy conservation standards for residential-duty commercial water heaters in this NOPR. Chapter 5 of the NOPR TSD includes additional detail on the conversion of energy conservation standards to UEF for residential-duty commercial water heaters.

Issue 15: DOE seeks comment on its approach to convert the thermal efficiency and standby loss levels analyzed for residential-duty commercial water heaters to UEF.

Table IV.26 shows the UEF levels calculated for each combination of thermal efficiency level and standby loss level, using the conversion factors proposed in the April 2015 NOPR.

TABLE IV.26—UEF LEVELS CORRESPONDING TO THERMAL EFFICIENCY AND STANDBY LOSS LEVELS

Thermal efficiency level	Thermal efficiency (%)	Standby loss efficiency level			
		SL EL0	SL EL1	SL EL2	SL EL3
E_t EL0	80	0.57	0.60	0.60	0.61
E_t EL1	82	0.58	0.61	0.61	0.62
E_t EL2	90	0.67	0.69	....	....
E_t EL3	95	0.69	0.72	....	....
E_t EL4	97	0.70	0.73	....	....

D. Markups Analysis

The markups analysis develops appropriate markups in the distribution chain (*e.g.,* manufacturer markups, retailer markups, distributer markups, contractor markups, and sales taxes) to convert the estimates of manufacturer selling price derived in the engineering analysis to commercial consumer prices, which are then used in the LCC and PBP analysis and in the manufacturer impact analysis. DOE develops baseline and incremental markups based on the equipment markups at each step 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 commercial water heating equipment wholesalers/distributors, modular building manufacturers and wholesalers/distributors, retailers, and mechanical contractors and general contractors working on behalf of commercial consumers. The incremental markup relates the change in the manufacturer sales price of higher-efficiency models (the incremental cost increase) to the change in commercial consumer price.

Four different markets exist for commercial water heating 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 → Commercial Consumer
- Manufacturer → Manufacturer Representative → Mechanical Contractor → Commercial Consumer
- Manufacturer → Retailer → Mechanical Contractor → Commercial Consumer

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

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

In addition to these distribution channels, there are scenarios in which manufacturers sell commercial water heating equipment directly to a commercial consumer through a national account, or a commercial 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 → Commercial Consumer
- Manufacturer → Retailer → Commercial Consumer

In response to the October 2014 RFI, several stakeholders commented on distribution channels. First, stakeholders provided inputs regarding the types of distribution channels for commercial water heating equipment. Rheem agreed that the distribution channel types outlined in the October 2014 RFI were appropriate and sufficient to describe the existing U.S. market. (Rheem, No. 10 at p. 4) AHRI and Bradford White suggested that DOE should address a distribution channel that goes from a manufacturer to a manufacturer's representative, who then sells to the commercial consumer. (AHRI, No. 5 at p. 4; Bradford White, No. 3 at p. 2) DOE addressed this comment by incorporating a manufacturer's representative distribution channel in its markups analysis for the NOPR.

In the October 2014 RFI, DOE also sought input on the percentage of equipment distributed through the various types of distribution channels. 79 FR 62899, 62906 (Oct. 21, 2014). Rheem stated that the vast majority of commercial water heating equipment is distributed through the wholesale channel. (Rheem, No. 10 at p. 4) DOE assumes that Rheem's responses reflect its experience, rather than a characterization of the industry overall. For this document, DOE estimated the percentage of shipments going through each distribution channel for each equipment class. The majority of shipments were allocated to the wholesaler channel, ranging from 60 to 70 percent, depending on the equipment class and market type.

Last, DOE asked in the October 2014 RFI for recent data and recommendations to establish the markups for the parties involved with the distribution of the equipment. 79 FR 62899, 62906 (Oct. 21, 2014). In response, Rheem stated that the markups varied within each market, making it difficult to roll up to a total market analysis. Distributors and their commercial consumers were reticent to provide Rheem with markup data. (Rheem, No. 10 at p. 4) DOE acknowledges that private businesses were reticent to provide potentially sensitive information about pricing to other market participants or DOE. To develop markups for this NOPR, DOE utilized several sources, including: (1) The Heating, Air-Conditioning & Refrigeration Distributors International (HARDI) 2013 Profit Report [41] to develop wholesaler markups; (2) the 2005 Air Conditioning Contractors of America's (ACCA) financial analysis for the heating, ventilation, air-conditioning, and refrigeration (HVACR) contracting industry [42] to develop mechanical contractor markups; (3) the U.S. Census Bureau's 2007 Economic Census data [43] for the commercial and institutional building construction industry to develop mechanical and general contractor markups; and (4) the U.S. Census Bureau's 2012 Annual Retail Trade Survey [44] 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.[45] 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.

Issue 16: DOE seeks comment on the percentages of shipments allocated to the distribution channels relevant to each equipment class.

Issue 17: DOE requests comment on the estimated market and sector weights for shipments by equipment class.

Issue 18: DOE requests comment on the development of markups at each point in the distribution chain and the overall markup by equipment class.

E. Energy Use Analysis

The purpose of the energy use analysis is to assess the energy requirements (*i.e.,* annual energy consumption) of commercial water heating (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 and energy-savings potential in the LCC and PBP analysis to establish the operating cost savings at various equipment efficiency levels.[46] DOE estimated the annual energy consumption of CWH equipment at specified energy efficiency levels across a range of climate zones, building characteristics, and water heating applications. The annual energy consumption includes use of natural gas, liquefied petroleum gas (LPG), or electricity for hot water production, 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 class 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 [47] to develop gallons-per-day hot water loads for the analyzed commercial building types.[48] DOE assigned these hot water loads on a square-foot basis to associated commercial building records in the EIA's 2003 Commercial Building Energy Consumption Survey [49] (CBECS) 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." [50] DOE applied this model to the residential building records in the EIA's 2009 Residential Energy Consumption Survey (RECS).[51] 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 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 they 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 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

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

[42] Air Conditioning Contractors of America (ACCA). *Financial Analysis for the HVACR Contracting Industry: 2005.*

[43] U.S. Census Bureau. 2007 Economic Census Data (2007) (Available at: *http://www.census.gov/econ/).*

[44] U.S. Census Bureau. 2012 Annual Retail Trade Survey (2012) (Available at: *http://www.census.gov/retail/*).

[45] *The Sales Tax Clearing House* (2014) (Available at: *www.thestc.com/STrates.stm*) (Last accessed Feb. 7, 2014).

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

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

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

[49] U.S. Energy Information Administration (EIA). *2003 Commercial Building Energy Consumption Survey (CBECS) Data* (2003) (Available at: *http://www.eia.gov/consumption/commercial/data/2003/*).

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

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

by using an equation that multiplies a building's gallons-per-day consumption of hot water by the density of water,[52] specific heat of water,[53] and the hot water temperature rise. To calculate temperature rise, DOE developed monthly dry bulb temperature estimates for each U.S. State using typical mean year (TMY) temperature data as captured in location files provided for use with the DOE EnergyPlus Energy Simulation Software.[54] Then these dry bulb temperatures were used to develop inlet water temperatures using an equation and methodology developed by the National Renewable Energy Laboratory (NREL).[55] DOE took the difference between the building's water heater setpoint temperature and inlet temperature to determine temperature rise. 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 using the calculations from a major water heater manufacturer's sizing calculators,[56] which were considered more comprehensive in their maximum hot water load calculations than other publicly-available sizing calculators. This methodology was applied to commercial building records in 2003 CBECS and residential building records in 2009 RECS to 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 class to determine the number of water heater units required to service the maximum load. For buildings with maximum load durations of two or three hours, DOE divided maximum loads by the two- or three-hour delivery capability of the baseline representative model. For each equipment class, 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 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 [57] for sizing of gas-fired tankless water heaters to develop the adjustment factors. Gas-fired 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.

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 class 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 storage water heaters, DOE used the standby loss levels identified in the engineering analysis to estimate energy savings from more-stringent standby loss levels. Section IV.C.3.b and Chapter 5 of the NOPR TSD include additional details on the standby loss levels analyzed in the engineering analysis.

For this NOPR, DOE also consulted the ASHRAE [58] and Electric Power Research Institute (EPRI) [59] 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.

In response to the proposed method of determining water heating energy use in the RFI, stakeholders expressed concerns regarding the climate zones in DOE's annual energy consumption analysis for commercial water heating equipment. In general, the commenters emphasized the importance of appropriately sizing the equipment under analysis for water heating energy use. A.O. Smith commented that "analysis across climate zones is unnecessary except for air-source HPWH's, as incoming water temperature is a more determinate parameter for other technology classes." (A.O. Smith, No. 2 at p. 3) Along the same lines, AHRI commented that it was overly complicated to have the proposed annual energy consumption analysis consider a range of applications of building types and climate zones. According to AHRI, the analysis should assume that the water heating equipment had been sized to meet the building load, regardless of building type or location. (AHRI, No. 5 at p. 4) In addition, Bradford White commented that the approach of the Energy Use Analysis was too involved and needed to be simplified. (Bradford White, No. 3 at p. 2) AHRI also commented that DOE could use manufacturers' sizing tools to size water heaters to the right application. (AHRI, No. 5, at pp. 4–5) AHRI cautioned that sizing methods are different than overall usage profiles. (AHRI, No. 5 at pp. 4–5) Rheem Manufacturing Company commented that commercial water heating equipment should be sized to meet the building's peak demand. (Rheem, No. 10 at p. 5) Lastly, Steffes recommended that DOE should use RECS 2009 in its analysis (particularly Table CE4.6). (Steffes, No. 6 at p. 2)

In the October 2014 RFI, DOE sought input and sources of data or

[52] DOE used 8.29 gallons per pound.

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

[54] U.S. Department of Energy—Office of Energy Efficiency and Renewable Energy. *EnergyPlus Energy Simulation Software,* TMY3 data (Available at: *http://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).

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

[56] A.O. Smith, *Pro-Size Water Heater Sizing Program* (Available at: *http://www.hotwatersizing.com/*) (Last accessed in March 2015).

[57] PVI Industries Inc., "Water Heater Sizing Guide for Engineers," Section X, pp 18–19 (Available at: *http://sizing.pvi.com/PV592%20Sizing%20Guide%2011-2011.pdf*).

[58] American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc. (ASHRAE), *ASHRAE Handbook of HVAC Applications: Chapter 50 (Service Water Heating)* (2011) pp. 50.1–50.32 (Available at: *https://www.ashrae.org/resources-publications/handbook*).

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

recommendations for tools to support sizing of CWH equipment typically found in commercial and residential applications. 79 FR 62899, 62907 (Oct. 21, 2014). In response, Rheem Manufacturing Company commented that it had an online tool for projecting hot water demand, found online at *http://www.rheem.com/certispec.* (Rheem, No. 10 at p. 5) A.O. Smith responded that most manufacturers, including A.O. Smith, have sizing calculators on their Web site, citing its own sizing calculators at *http://www.hotwatersizing.com* and *http://www.lochinvar.com/sizingguide.aspx.* (A.O. Smith, No. 2 at p. 3) Bradford White commented that its Web site had the RightSpec® Product Sizing Guide to size water heating systems to commercial applications. (Bradford White, No. 3 at p. 3)

DOE considered these comments in designing its energy use analysis. As recommended by Steffes, DOE utilized 2009 RECS building characteristics data for determining residential building hot water loads and maximum load sizing requirements. DOE also used 2003 CBECS building characteristics data for determining commercial building hot water loads and maximum load sizing requirements. While recognizing AHRI and Bradford White's concern for the complexity of the analysis, DOE determined that assessing the energy use of CWH equipment across a range of operating applications and climates specific to the building types and locations in the 2009 RECS and 2003 CBECS data improves the estimated hot water load associated with equipment sized for the applications. This analytical approach enables DOE to evaluate the impacts of the proposed energy conservation standards comprehensively, accounting for the hot water requirements of U.S. commercial consumers across a multitude of scenarios.

A.O. Smith and AHRI expressed concerns about analyzing the energy use of CWH equipment across climate zones. Based on the comment received, DOE believes that this concern was unfounded. As discussed previously, DOE's analysis utilized climate zone data, in the form of location-based dry bulb temperature data, which was then used to estimate the inlet water temperature specific to each sampled building's location, a key parameter identified by A.O. Smith. This approach captured the effect of inlet water temperature on CWH equipment hot water loads and maximum load sizing. As recommended by AHRI, Rheem, A.O. Smith, and Bradford White, DOE used a major manufacturer's peak sizing calculators as the basis for sizing CWH equipment to the maximum hot water loads predicted for the sampled CBECS and RECS building records.

For details of DOE's energy use analysis, see chapter 7 of the NOPR TSD.

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 commercial 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 commercial consumer impacts:

- The LCC (life-cycle cost) is the total consumer cost of an appliance or equipment over the life of the equipment. The LCC calculation includes total installed cost (equipment manufacturer selling price, distribution chain markups, sales tax, and installation costs), operating costs (energy, repair, and maintenance costs), product lifetime, and discount rate. DOE discounts future operating costs to the time of the purchase using a commercial consumer discount rate.
- The PBP (payback period) is the estimated amount of time (in years) it takes commercial consumers to recover the increased total installed cost (including equipment and installation costs) of a more-efficient type of equipment through reduced operating costs. DOE calculates the PBP by dividing the change in total installed cost (normally higher) due to a proposed new or amended energy conservation standard by the change in annual operating cost (normally lower) that results from that potential standard. For a given efficiency level, DOE measures the change in LCC, or the LCC savings, relative to an estimate of the no-new-standards-case efficiency level. The no-new-standards-case estimates reflect the market in the absence of amended energy conservation standards, including market trends for equipment that exceed the current energy conservation standards.

For the 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. DOE utilized the sample of buildings developed for the energy use analysis and the corresponding simulations results.[60] DOE expressed the LCC and PBP results on a single, per-unit, commercial water heating equipment basis, considered at each thermal efficiency and standby loss level. In addition, DOE reported the LCC results as the percentage of CWH equipment consumers experiencing differing economic impacts (LCC savings of greater than 0 indicate net benefit; LCC savings of less than 0 indicate net cost; and LCC savings equal to 0 indicate no impact).

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, performed by Crystal Ball (a commercially-available software program), randomly sampled input values from each of the probability distributions. Then, the model calculated the LCC and PBP for equipment at each efficiency level for the 10,000 simulations. More details on the incorporation of uncertainty and variability in the LCC are available in appendix 8B of the NOPR TSD.

DOE conducted the LCC and PBP analyses using a commercially-available spreadsheet tool and a purpose-built spreadsheet model, available on DOE's Web site.[61] 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 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 and described in detail in chapter 8 of the NOPR TSD.

EPCA establishes a rebuttable presumption that a standard is economically justified if the Secretary finds that the additional cost to the consumer of purchasing a product complying with an energy conservation standard level will be less than three times the value of the energy (and, as applicable, water) savings during the first year that the consumer will receive

[60] DOE utilized the building types defined in CBECS 2003, as well as residential buildings defined in RECS 2009. More information on the types of buildings considered is discussed later in this section. (CBECS: *http://www.eia.gov/consumption/commercial/data/2003/*) (RECS: *http://www.eia.gov/consumption/residential/*) (Both links last accessed on 04/06/2015).

[61] DOE's Web page for commercial water heating equipment is available at: *https://www1.eere.energy.gov/buildings/appliance_standards/standards.aspx?productid=36.*

as a result of the standard, as calculated under the test procedure in place for that standard. For each considered efficiency level, DOE typically determines the value of the first year's energy savings,[62] and multiplies that amount by the average energy price forecast for the year in which compliance with the amended standards would be required. This value, in conjunction with equipment cost, was used in a rebuttable payback calculation for each equipment class.

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 discussed above, DOE is conducting this rulemaking pursuant to its 6-year-lookback authority under 42 U.S.C. 6313(a)(6)(C), and EPCA directs DOE to publish a final rule amending the standard for the equipment covered in this document no later than 2 years after a NOPR is issued. (42 U.S.C. 6313(a)(6)(C)(iii)) At the time of preparation of the NOPR analyses, the expected issuance date was 2015, leading to an anticipated final rule publication in 2016. EPCA also states that amended standards prescribed under this subsection shall apply to equipment manufactured after a date that is 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), currently projected to be 2019, 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, 2019 as the beginning of compliance with potential amended standards for CWH equipment.

As noted above, 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).

In the October 2014 RFI, DOE requested comment from stakeholders on the overall method that it intended to use in conducting the LCC and PBP analysis for CWH equipment. 79 FR 62899, 62907 (Oct. 21, 2014). In response to this request, several stakeholders provided comment. A. O. Smith and Rheem stated that the LCC and PBP methods were acceptable but were dependent upon accurate assumptions and data. (A. O. Smith, No. 2 at p. 3; Rheem, No. 10 at p. 6) AHRI agreed, and mentioned potential issues in selecting the inputs for the analysis. (AHRI, No. 5 at p. 4) Bradford White further stated that while it had no issue with the proposed method for the LCC and PBP analyses, it would like representative cost estimates to be used. (Bradford White, No. 3 at p. 3)

1. Approach

Recognizing that each business 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 89.1 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 commercial consumers in each business and building type. Each type of building has typical commercial 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 Web site.[63] 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.[64]

The LCC analysis used the estimated annual energy use for every unit of CWH equipment described in section IV.C. 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 commercial 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 commercial 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.27 summarizes the inputs and key assumptions DOE used to calculate the commercial consumer economic impacts of all energy efficiency levels analyzed in this rulemaking. A more detailed discussion of the inputs follows.

[62] The DOE test procedure for commercial water heating 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.

[63] *Damodaran Online* (Commercial Applications) (Available at: *http://pages.stern.nyu.edu/~adamodar/New_Home_Page/home.htm*) (Last accessed on 04/04/2015).

[64] The real interest rates data for the six income groups (residential sector) can be obtained from the Survey of Consumer Finances. The Federal Reserve Board. *Survey of Consumer Finances.* 1989, 1992, 1995, 1998, 2001, 2004, 2007, 2010 (Available at: *http://www.federalreserve.gov/pubs/oss/oss2/scfindex.html*). Survey of Consumer Finances (Estimate using 1995, 1998, 2001, 2004, 2007, and 2010 databases) (Residential Applications) (Available at: *http://www.federalreserve.gov/econresdata/scf/aboutscf.htm*) (Last accessed on May 14, 2015).

TABLE IV.27—SUMMARY OF INPUTS AND KEY ASSUMPTIONS USED IN THE LCC AND PBP ANALYSES

Inputs	Description
Affecting Installed Costs	
Equipment Price	Equipment price 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 2015 data books [a b c] and converted to 2014$.
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, and Oil Prices.	DOE developed average residential and commercial electricity prices based on EIA Form 861 data for 2013.[d] Future electricity prices are projected based on *AEO 2015.* DOE developed residential and commercial natural gas prices based on EIA State-level prices in EIA *Natural Gas Navigator.*[e] Future natural gas prices are projected based on *AEO 2015.*
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	
Equipment Lifetime	Table IV.29 provides lifetime estimates for equipment class. DOE estimated that the average CWH equipment lifetimes range between 10 and 25 years, with the average lifespan dependent on equipment class based on estimates cited in available literature.[g h]
Discount Rate	Mean real discount rates (weighted) for all buildings range from 3.6% to 5.1%, for the six income bins relevant to residential applications. For commercial applications, DOE considered mean real discount rates (weighted) from ten different commercial sectors, and the rates ranged between 3.5% and 6%.
Analysis Start Year	Start year for LCC is 2019, which is the anticipated compliance date for any potential amended standards if 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. DOE also analyzed baseline and up to three higher efficiency standby loss levels. See the engineering analysis for additional details on selections of efficiency levels and costs.

[a] RSMeans, *RSMeans Building Construction Cost Data 2015,* 73rd ed. (2014) (Available at: *http://www.rsmeans.com*).
[b] RSMeans, *RSMeans Contractor's Pricing Guide Residential Repair & Remodeling Costs 2015* (2014) (Available at: *http://www.rsmeans.com*).
[c] RSMeans, *RSMeans Mechanical Cost Data 2015.* 38th Annual ed. (2014) (Available at: *www.rsmeans.com*).
[d] U.S. Energy Information Administration (EIA), Electric Sales, Revenue, and Average Price 2013: Select table Sales and Revenue Data by State, Monthly Back to 1990 (Form EIA–826) (Available at: *http://www.eia.gov/cneaf/electricity/page/sales_revenue.xls*) (Last accessed on 04/04/2015).
[e] U.S. Energy Information Administration (EIA), Average Price of Natural Gas Sold to Commercial Consumers—by State (Available at: *http://www.eia.gov/dnav/ng/ng_pri_sum_a_EPG0_PCS_DMcf_a.htm*) (Last accessed on 04/04/2015).
[f] U.S. Energy Information Administration (EIA), State Energy Data System (SEDS) (Available at: *http://www.eia.gov/state/seds/*) (Last accessed 04/04/2015).
[g] American Society of Heating, Refrigerating, and Air-Conditioning Engineers, *2011 ASHRAE Handbook: Heating, Ventilating, and Air-Conditioning Applications* (2011) (Available at: *https://www.ashrae.org/resources-publications*).
[h] Abramson, B., D. Herman, and L. Wong, *Interactive Web-based Owning and Operating Cost Database* (2005) Final Report ASHRAE Research Project RP–1237 (Available at: *https://www.ashrae.org/resources-publications*).

a. Equipment Prices

The price of CWH equipment reflects the application of distribution channel markups (mechanical contractor markups) and sales tax to the MSP, which is the cost established in the engineering analysis. As described in section IV.D, DOE determined distribution channel costs and markups for commercial water heating equipment. For each equipment class, the engineering analysis provided contractor costs for the baseline equipment and up to five higher equipment efficiencies. DOE examined whether equipment prices for CWH equipment would change over time. DOE tentatively determined that there is no clear historical price trend for CWH equipment. Therefore, DOE used costs established in the engineering analysis directly for determining 2019 equipment prices and future equipment prices (equipment is purchased by the commercial consumer during the first year in 2019 at the estimated equipment price, after which the equipment price remains constant). See section IV.H.3 of this document and appendix 10B of the NOPR TSD for more details.

The markup is the percentage increase in price as the CWH equipment passes through distribution channels. As explained in section IV.D, 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 commercial water heating equipment. The overall markups used in the LCC analysis are weighted averages of all of the relevant distribution channel markups.

UM was concerned that this rulemaking would quickly drive up the cost of water heaters without addressing the inefficiencies of related systems. (UM, No. 9 at p. 2) In response, DOE does address the inefficiencies of building systems, including water heating systems, through its Building Energy Codes Program. However, the present CWH rulemaking is initiated as part of the Appliances and Equipment Standards Program, and through this program, DOE can only set equipment standards that are technologically feasible and economically justified, but does not address other inefficiencies found in building systems.

b. Installation Costs

The primary inputs for establishing the total installed cost are the baseline commercial consumer price, standard-level commercial consumer price increases, and installation costs (labor and material costs), where the primary installation costs changes, by efficiency level, are the venting costs for high-efficiency gas-fired products. Baseline commercial consumer prices and standard-level commercial consumer price increases will be determined by applying markups to manufacturer selling price estimates, including sales tax where appropriate. For new installations, the installation cost is added to the commercial consumer price to arrive at a total installed cost. For replacement installations, the cost to remove the previous equipment (including venting when necessary) and the installation cost for new equipment are added to the commercial consumer price to arrive at the total replacement installation cost.

In the October 2014 RFI, DOE stated that it intended to develop installation costs using the most recent RS Means data.[65] [66] [67] [68] [69] 79 FR 62899, 62907 (Oct. 21, 2014). In addition, DOE sought inputs on its approach of using RS Means to develop installation costs. *Id.* Several stakeholders commented on the data sources for the installation cost analysis. AHRI commented that it was not familiar enough with the development process of the RS Means Mechanical Cost Data to be confident in its accuracy. (AHRI, No. 5 at p. 5) A. O. Smith also commented that it was not familiar enough with the development process of the RS Means Mechanical Cost Data to be confident in its accuracy. (A. O. Smith, No. 2 at p. 3) Rheem opined that RS Means Mechanical Cost Data was not appropriate for LCC and PBP analysis. Rheem commented that installation cost was a function of fuel input, and replacement installation was double the cost of new construction installation. (Rheem, No. 10 at p. 6)

To summarize DOE's approach, DOE derived national average installation costs for commercial equipment from data provided in RS Means 2015 data books.[70] 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 all 50 States and 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 commercial 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. In response to the comments received, DOE compared the RS Means data to other publically-available sources of similar national information, specifically Engineering News-Record (ENR)[71] and Whitestone Research.[72] Specifically, this approach was intended to address the concerns of Joint Advocates, as no independent calibration of the RS Means data was readily available. (Joint Advocates, No. 7 at p. 4) Generally, the RS Means data were found to be in agreement with other national sources. In certain specific instances when the RS Means data were found to be significantly higher than the average, DOE scaled the RS means relationship to represent the average of the available data sources. In the specific cases where the modeled labor hours resulted in excessive amounts of time in a given day, the number of laborers in the crew was increased by one person, while the labor hour calculations were reduced by a factor. This approach is in agreement with Rheem's comment that the water heater is a critical building component and will be repaired or replaced quickly to maintain operation of the building. (Rheem, No. 10 at p. 7) As none of the received comments identified alternative sources of data, and with this comparison complete, DOE confirms the RS Means data to be sufficient for this analysis.

For products requiring venting, DOE calculated venting costs for each building in the Commercial Building Energy Consumption Survey (CBECS) and Residential Energy Consumption Survey (RECS). A variety of installation parameters impact venting costs; among these, DOE simulated the type of installation (new construction or retrofit), draft type (atmospheric venting or power venting), water heater fuel type, building vintage, number of stories, and presence of a chimney. A logic sequence was applied to the identified variables in order to accurately determine the venting costs for each instance of equipment and building within the Monte Carlo analysis. 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 products with vent diameters smaller than 5 inches were modeled using PVC (polyvinyl chloride) as the vent material.
- Condensing products with vent diameters larger than 8 inches were modeled using AL29–4C as the vent material.
- Condensing products with vent diameters of 5 inches and up to and including 8 inches were modeled using a random selection process where on average 50 percent of installations use PVC as the vent material and the remaining use AL29–4C.
- 5 percent of all condensing water heater installations were modeled as direct vent installations, where flue lengths would allow. The intake air pipe material for condensing products was modeled as PVC.

Additional details of the venting logic sequence can be found in Chapter 8 of the NOPR TSD. In addition, total installed costs can be found below in tables V.4, V.6, V.8, V.10, and V.14.

Issue 19: DOE seeks comment on the assumptions used in determining the venting costs for the relevant types of CWH equipment.

Issue 20: DOE seeks comment on the percentage of installations using polypropylene venting materials in this industry and any limitations such venting has as to maximum available diameters or other limitations.

[65] RSMeans, RSMeans Building Construction Cost Data 2015. 73rd ed. (2014) (Available at: *http://www.rsmeans.com*).

[66] RSMeans, RSMeans Contractor's Pricing Guide Residential Repair & Remodeling Costs 2015 (2014) (Available at: *http://www.rsmeans.com*).

[67] RSMeans, RSMeans Mechanical Cost Data 2015. 38th Annual ed. (2014) (Available at: *http://www.rsmeans.com*).

[68] RSMeans, RSMeans Electrical Cost Data 2015. 38th Annual ed. (2014) (Available at: *http://www.rsmeans.com*).

[69] RSMeans, RSMeans Plumbing Cost Data 2015. 38th Annual ed. (2014) (Available at: *http://www.rsmeans.com*).

[70] DOE notes that RS Means publishes data books in one year for use the following year; hence, the 2015 data book was published in 2014.

[71] Engineering News-Record, *Mechanical Contracting Costbook 2015 Edition,* Volume 8 (2014). McGraw-Hill Publishing Company, Inc.: New York, NY.

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

DOE recognized that basic installation costs are higher for larger units, but did not identify any significant basic installation cost increases for higher-efficiency CWH equipment. These relationships were consistent in the RS Means data. Therefore, DOE utilized RS Means installation cost data to derive installation cost curves by equipment size. As the data sources available to DOE did not have data to calibrate the extent to which installation costs might change as efficiency increased, DOE assumed for the NOPR LCC analysis that basic installation cost would not increase as a function of increased efficiency.

Rheem argued that the labor cost to remove a product was equal to the labor cost to install an identical appliance. (Rheem, No. 10 at p. 7) Determination of the amount of labor was expected to be either a constant percentage based upon the installation cost, as suggested by Rheem, or a linear relationship of the percentage of the installation cost related to the volume of the tank in question. However, inspection of the available RS Means data demonstrated that the labor required for removing a storage tank smaller than approximately 250 gallons required approximately 20 percent of the labor necessary to complete the installation. The percentage of labor required for removal, compared to the labor required for installation, continued to increase with the storage volume until it reached approximately 54 percent of installation labor at a volume of 1,200 gallons. This relationship was observed to be non-linear in nature, which would significantly complicate the analysis, and did not agree with stakeholder feedback or DOE's understanding of the costs.

Therefore, DOE estimated the labor required to remove CWH equipment by averaging the calculated percentage of labor to remove a water heater compared to the amount of labor required to install the water heater with respect to the storage volume. As reported in RS Means data, the average percentage of removal labor hours in terms of installation labor hours was found to be 37.5 percent of the labor to install a water heater, and this percentage was used to determine the amount of labor required to remove a given unit of CWH equipment at the end of service condition.

DOE did not find a source of data on the cost for venting system removal. However, DOE understands that removal of venting requires many similar tasks in handling components as installation does, but without the same necessary care to ensure vent integrity. As found in the equipment removal cost, the amount of labor required for removing venting is less than the amount of labor required to install said venting. Furthermore, DOE notes that the amount of labor required for removal of the venting will increase significantly as the venting diameter increases due to the difficulty of managing the components during removal. Therefore, DOE modeled the labor required to remove an existing venting system as 50 percent of the labor required to complete an installation of a new venting system, as this presents a conservative estimate of the amount of labor required for removal.

Issue 21: DOE seeks comment on the installation labor and labor to remove equipment and venting in this analysis.

Issue 22: DOE seeks comment on the overall installed costs by TSL for each equipment class as shown in the Average LCC and PBP Results tables found in section V.B.1.a, Table V.4 through Table V.14.

c. Annual Energy Use

DOE estimated the annual electricity and natural gas consumed by each class 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.

d. Electricity and Natural Gas 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 [73] and commercial natural gas prices [74] at the State level from Energy Information Administration (EIA) data for 2014. DOE used data from EIA's Form 861 [75] to calculate commercial and residential sector electricity prices, and EIA's Natural Gas Navigator [76] to calculate commercial and residential sector natural gas prices. Future energy prices were projected using trends from the EIA's *AEO 2015*.[77] 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 chapter 8 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 *AEO 2015* 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 2040.

Several stakeholders suggested further items to consider for the electricity and gas price analysis. Steffes stated that using average electric rates where demand and energy charges were bundled together in LCC and PBP calculations would often fail to capture financial impact. (Steffes, No. 6 at p. 2) Bradford White recommended that DOE reach out to the Energy Solutions Center for natural gas pricing. (Bradford White, No. 3 at p. 3) AGA recommended that DOE use marginal gas-price analysis when evaluating monetary savings in the LCC, arguing that a shift from a non-condensing water heater to a condensing water heater would not alter fixed costs. (AGA, No. 4 at p. 5) DOE considered each of these comments carefully, and in response, developed the LCC analysis using a marginal fuel price approach to convert fuel savings into corresponding financial benefits for the different equipment classes. 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

[73] U.S. Energy Information Administration (EIA), Form EIA–826 Database Monthly Electric Utility Sales and Revenue Data (EIA–826 Sales and Revenue Spreadsheets) (Available at: *http://www.eia.gov/electricity/data/eia826/* On the right side of the screen under Aggregated, select 1990–current). (Last accessed on 04/04/2015.)

[74] U.S. Energy Information Administration (EIA), Natural Gas Prices (Available at: *http://www.eia.gov/dnav/ng/ng_pri_sum_a_EPG0_PCS_DMcf_a.htm*) (Last accessed on 04/04/2015).

[75] U.S. Energy Information Administration (EIA), Survey form EIA–861—Annual Electric Power Industry Report (Available at: *http://www.eia.gov/electricity/data/eia861/index.html*) (Last accessed on 04/04/2015).

[76] U.S. Energy Information Administration (EIA), Natural Gas Navigator (Available at: *http://tonto.eia.doe.gov/dnav/ng/ng_pri_sum_dcu_nus_m.htm*) (Last accessed on 04/04/2015).

[77] U.S. Energy Information Administration (EIA), *2015 Annual Energy Outlook* (2015) Full report. DOE/EIA–0383(2015) (Available at: *http://www.eia.gov/forecasts/aeo/*) (Last accessed on 04/04/2015).

marginal fuel price approach, see chapter 8 of the NOPR TSD.

e. Maintenance Costs

Maintenance costs are the routine annual costs to the commercial consumer of ensuring continued equipment operation. DOE utilized The Whitestone Facility Maintenance and Repair Cost Reference 2012–2013 [78] 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 anodes. DOE estimated average annual routine maintenance costs for each class of CWH equipment based on equipment groupings. Table IV.28 presents various maintenance services identified and the amount of labor required to service each equipment class in this analysis.

TABLE IV.28—SUMMARY OF MAINTENANCE LABOR HOURS AND SCHEDULE USED IN THE LCC AND PBP ANALYSES

Equipment class	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 water heaters and hot water supply boilers.	Service	0.33	1
Electric storage water heaters	Check	0.33	3
	Drain & Flush (Volume ≤30 gallons)	2.67	7
	Drain & Flush (Volume >30 gallons)	4	7

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 TSD.

Issue 23: DOE seeks comment on maintenance labor estimates used in the LCC analysis and the assumption that maintenance costs remain constant as efficiency increases.

f. Repair Costs

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

In the October 2014 RFI, DOE sought input on its intention to use the most recent RS Means Facilities Maintenance & Repair Cost data for developing maintenance costs. 79 FR 62899, 62908 (Oct. 21, 2014). Joint Advocates stated they were not aware of studies with independent calibration of RS Means Facilities Maintenance & Repair Cost data and suggested that DOE could survey a metropolitan area to perform such a calibration. (Joint Advocates, No. 7 at p. 4) Rheem commented that RS Means Facilities Maintenance & Repair Cost data presented best practices but stated that there are a wide range of practices in the field. (Rheem, No. 10 at p. 7) A.O. Smith and AHRI commented that each was not familiar enough with the development process of the RS Means Facilities Maintenance & Repair Cost Data to be confident in its accuracy. (A.O. Smith, No. 2 at p. 4; AHRI, No. 5 at p. 5)

In response to these comments, DOE conducted further research to identify alternative sources of data relating to the repair of CWH equipment and identified The Whitestone Facility Maintenance and Repair Cost Reference 2012–2013 [79] as an alternative source of information. Upon evaluation of the Whitestone Research data, and in consideration of the comments received, DOE adopted a simplified analysis for repairs. Specifically, although the Weibull probability distribution may be utilized, Joint Advocates and Rheem consider this approach to generalize equipment failure rates, and hence maintenance rates, across environmental conditions, installation variations, design approaches, and manufacturing processes which have changed with time. (Joint Advocates, No. 7 at p. 4; Rheem, No. 10 at p. 8) As an alternative to Weibull probability distribution, for this aspect of the analysis, DOE calculated repair costs based on an assumed typical product level failure rate of 2 percent per year, with an additional assumption of an average of five components that are field replaceable during the equipment's lifetime. These assumptions equate to a component failure rate of 0.4 percent of shipments per year. This repair rate extends through the life of the equipment.

The labor required to replace a component was estimated as 2 hours for combustion systems, 1 hour for combustion controls, and ¾ hour to replace an electric water heater thermostat. The Department estimates that a service technician would require 3 hours on average to replace an electric heating element, accounting for the time required to drain a storage tank prior to element replacement and refilling the tank afterwards.

In the October 2014 RFI, DOE asked if repair costs vary as a function of equipment efficiency. 79 FR 62899, 62908 (Oct. 21, 2014). Several stakeholders commented on the relationship between equipment efficiency and repair costs. Bradford White, A.O. Smith, and AHRI commented that to the extent that higher-efficiency equipment incorporates additional components and more complex controls, the repair costs would likely be higher. (Bradford White, No. 3 at p. 3; A.O. Smith, No. 2 at p. 4; AHRI, No. 5 at p. 5) Along the same line, Rheem stated that repair costs could be greater for new, more-efficient technologies. These repairs were more frequent, required more labor hours, and had parts that were less likely to be available and may require the cost of premium freight. (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.

The combustion systems and controls used in gas-fired CWH equipment were found to have different costs related to the efficiency levels of these products. This is in agreement with comments provided by AHRI, Bradford White,

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

[79] The Whitestone Facility Maintenance and Repair Cost Reference 2012–2013, 17th Annual ed. (2012) Whitestone Research: Santa Barbara, CA (Whitestone Research) (Available at: *http://whitestoneresearch.com/CBRE-Store/Books.html*).

Rheem, and A.O. Smith (AHRI, No. 5 at p. 5; Bradford White, No. 3 at p. 3; Rheem, No. 10 at p. 7; A.O. Smith, No. 2 at p. 4). 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.

A simpler analysis was used to account for repair costs in the LCC model for electric water heaters. Component costs used in repairs were taken from average prices found on manufacturers' Web sites, Grainger.com, and Internet searches.

The repair cost of equipment with multiple service parts was estimated as the average cost of all of the components identified in the Internet search. 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 commercial consumer price and the total installation price. 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 are found in Chapter 8 of the NOPR TSD and Appendix 8E of the NOPR TSD.

Issue 24: DOE seeks comment on the findings of the repair costs of CWH equipment, labor estimates for repairs, and the estimated rate of component repair.

g. Equipment Lifetime

Equipment lifetime is the age when a unit of CWH equipment is retired from service. In the October 2014 RFI, DOE presented various sources that estimate the average lifetime for CWH equipment to be between 7 and 25 years based on the application and equipment class. 79 FR 62899, 62908 (Oct. 21, 2014). In addition, DOE stated in the October 2014 RFI that it intended to determine average lifetime for each CWH equipment class as the primary input for developing a Weibull probability distribution to characterize CWH lifetime. DOE sought comment on its approach of using a Weibull probability distribution to characterize equipment lifetime. *Id.*

In response to DOE's request for comment, Joint Advocates stated that Weibull survivorship was the ''least bad'' option for lifetime estimation. However, that method also assumed that changing water heater-related materials and processes relative to water heaters that have already died would not affect the lifetime of future units. Joint Advocates further pointed out that this assumption may not be valid, particularly for early generation of technologies. (Joint Advocates, No. 7 at p. 4) Lastly, Rheem agreed with DOE's approach of using Weibull probability distribution for lifetime analysis but cautioned that applications impact lifetime considerably. (Rheem, No. 10 at p. 8)

In response to the Joint Advocates' comment on Weibull survivorship, DOE acknowledges that changing equipment, water heater-related materials, and design processes may have an impact on future product life. DOE has not been able to obtain any information (nor have commenters provided such information) to assess how possible new designs and processes may impact future equipment life or how the use of early generation technologies informs or influences the life of equipment analyzed in this rule. Without such information, consistent with the Joint Advocates comment, DOE continued to assess lifetime of equipment in its analysis using historical data and a Weibull approach to allow for variability in equipment life within the LCC. Based on the parameters of the Weibull distribution, the lifetime for the equipment varies within each simulation run.

For the analysis of this NOPR, DOE did not obtain additional data that conflicted with its findings of an average lifetime between 10 and 25 years for different classes of CWH equipment. Consequently, DOE used a distribution of lifetimes, with the weighted averages ranging between 10 years and 25 years as shown in Table IV.29, based on a review of a range of CWH equipment lifetime estimates found in published studies and online documents. 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.29—AVERAGE CWH LIFETIME USED IN NOPR ANALYSES

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

h. Discount Rate

The discount rate is the rate at which future expenditures are discounted to establish their present value. 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.

To estimate the WACC of CWH equipment purchasers, DOE used a sample of more than 340 companies grouped to be representative of operators of different businesses, drawn from a database of 7,766 U.S. companies presented on the Damodaran Online Web site.[80] This database includes most of the publicly-traded companies in the United States. The WACC approach for determining discount rates accounts for the current tax status of individual firms on an overall corporate basis. DOE did not evaluate the marginal effects of

[80] *Damodaran Online.* Damodaran financial data used for determining cost of capital (Available at: *http://pages.stern.nyu.edu/~adamodar/*) (Last accessed on 04/05/2015).

increased costs, and, thus, depreciation due to more expensive equipment, on the overall tax status.

DOE used the final sample of companies to represent purchasers of CWH equipment. For each company in the sample, DOE derived the cost of debt, percentage of debt financing, and systematic company risk from information on the Damodaran Online Web site. Damodaran estimated the cost of debt financing from the nominal long-term Federal government bond rate and the standard deviation of the stock price. DOE then determined the weighted average values for the cost of debt, range of values, and standard deviation of WACC for each category of the sample companies. 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).[81] 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.[82]

Based on this database, DOE calculated the weighted-average, after-tax discount rate for CWH equipment purchases, adjusted for inflation. Chapter 8 of the NOPR TSD contains the detailed calculations related to discount rates.

3. Payback Period

DOE also determined the economic impact of potential amended energy conservation standards on commercial consumers by calculating the PBP of more-stringent efficiency levels relative to the baseline efficiency levels. The PBP measures the amount of time it takes the commercial consumer to recover the assumed higher purchase expense of more-efficient equipment through lower operating costs. Similar to the LCC, the PBP is based on the total installed cost and the operating expenses for all building types and purchase locations for the water-heating equipment. Because the simple PBP does not take into account changes in operating expense over time or the time value of money, DOE considered only the first year's operating expenses, including annualized repair and maintenance expenses, to calculate the PBP, unlike the LCC, which is calculated over the lifetime of the equipment. Chapter 8 of the NOPR TSD provides additional details about the PBP.

G. Shipments Analysis

In its shipments analysis, DOE developed shipment projections for commercial water heating equipment and, in turn, calculated equipment stock over the course of the analysis period. DOE uses the shipments projection and the equipment stock to calculate the national impacts of potential amended energy conservation standards on energy use, NPV, and future manufacturer cash flows. DOE develops shipment projections based on historical data and an analysis of key market drivers for each type of equipment.

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 1994–2013 from the AHRI Web site,[83] and extended back to 1989 with data contained in a DOE rulemaking document published in 2000.[84] The historical shipments of commercial electric and gas-fired storage water heaters are summarized in Table IV.30. Given that the estimated average useful lifetimes of these two types of equipment are 12 and 10 years, respectively, the historical shipments provided a basis for the development of a multi-year series of stock values. Using the stock values, a saturation rate was determined by dividing equipment stock by building stock, and this saturation rate was combined with annual building stock additions to estimate the shipments to new construction. With these data elements, a yearly accounting model was developed for the historical period to identify shipments deriving from new construction and from replacements of existing equipment. The accounting model also identified commercial 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.30—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

Source: AHRI web site, *http://www.ahrinet.org/site/494/Resources/Statistics/Historical-Data/Commercial-Storage-Water-Heaters-Historical-Data.*

No historical shipment information was available for residential-duty gas-fired storage water heaters, gas-fired tankless waters, or gas-fired hot water supply boilers. The stock accounting model requires historical stock and shipments, so DOE estimated past shipments for these equipment classes. The stock of equipment for each equipment class was developed in the same manner described for the gas-fired and electric storage water heaters.

For residential-duty gas-fired storage equipment, DOE assumed equivalency in shipments per basic model between the commercial and the residential-duty gas-fired storage water heaters. The ratio of the number of unique residential-duty gas-fired water heaters (67) to commercial gas-fired water heaters (328) listed in the analysis database was applied to the gas-fired water heater shipments, with the result being an estimated historical series of residential-duty gas-fired water heaters.

For gas-fired tankless water heaters, DOE used an estimation method discussed in industry sources (*e.g.,* the Consortium for Energy Efficiency).[85]

[81] Federal Reserve Bank of St. Louis, *State and Local Bonds—Bond Buyer Go 20-Bond Municipal Bond Index* (Available at: *http://research.stlouisfed.org/fred2/series/MSLB20/downloaddata?cid=32995*) (Last accessed 04/05/2015).

[82] Rate calculated with 1973–2013 data. Data source: U.S. Federal Reserve (Available at: *http://www.federalreserve.gov/releases/h15/data.htm*) (Last accessed on 04/05/2015).

[83] Air Conditioning, Heating, and Refrigeration Institute, *Commercial Storage Water Heaters Historical Data* (Available at: *http://www.ahrinet.org/site/494/Resources/Statistics/Historical-Data/Commercial-Storage-Water-Heaters-Historical-Data*) (Last accessed April 1, 2015).

[84] 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: *http://www.regulations.gov/#!documentDetail;D=EERE-2006-STD-0098-0015*).

[85] Consortium for Energy Efficiency (CEE), *CEE Commercial Water Heating Initiative Description* (2012) (Available at: *http://library.cee1.org/sites/default/files/library/7521/CEE_GasComm_WHInitiative_5Jun2012.pdf*).

This estimation method holds that tankless water heaters constitute 10 percent of the total CWH market. Because the only data widely available are for gas-fired and electric storage unit shipments, DOE implemented this by assuming that tankless water heaters constitute 10 percent of the total shipments of gas-fired storage water heaters, electric storage water heaters, and gas-fired tankless water heaters, and that the resulting number of tankless water heaters would be split between fuel types based on relative percentages of storage water heaters. DOE performed this calculation for 2013 shipments. Shipments were estimated for earlier years by applying a year-to-year growth rate in total imports and exports (net of re-exports) of gas-fired tankless water heaters obtained from a United Nations Web site.[86]

To estimate historical shipments of instantaneous water heaters and hot water supply boilers, DOE started with an estimate of the total stock of instantaneous equipment in commercial buildings for the year 2008.[87] Based on information derived from CBECS,[88] the DOE study estimated the total stock of instantaneous water heaters and hot water supply boilers in commercial buildings to be 600,000 units. However, because CBECS data do not distinguish well between residential-rated and commercial-rated equipment, it is likely that some residential-rated tankless equipment is included in the estimated total stock. Using the shipments of commercial tankless water heaters discussed in the prior paragraph, DOE estimated the 2008 stock of commercial tankless water heaters in commercial buildings and subtracted it from the total instantaneous stock. Since DOE believes the total stock of instantaneous equipment identified in the DOE study includes tankless units that are classified by DOE as residential equipment, to account for residential tankless units, DOE assumed that the residential and commercial tankless water heaters exist in the same numbers. The difference between the total instantaneous equipment stock and the stock of residential and commercial tankless water heaters is assumed to be the 2008 stock of hot water supply boilers. Shipments of hot water supply boilers were estimated simplistically by dividing the stock by the assumed 25-year life. The pre-2008 shipments were held constant for the 25 years leading up to 2008, and post-2008 shipments were generated by linking the 2008 value to the annual percentage change in gas-fired storage shipments.

To project shipments and stock for 2014 through the end of the 30-year analysis period (2048), DOE relied on a stock accounting model. For each class of equipment, DOE projected 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 *AEO 2015*.[89]

To project shipments of commercial water heating equipment for new construction, DOE relied on building stock data obtained from the *AEO 2015*. For this rulemaking, DOE assumes commercial water heating equipment is used in both commercial and residential buildings, including residential multi-family dwellings. 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 the *AEO 2015* are shown Table IV.31.

TABLE IV.31—BUILDING STOCK PROJECTIONS

Year	Total commercial building stock (million sq. ft.)	Commercial building stock additions (million sq. ft.)	Total residential building stock (millions of units)	Residential building additions (millions of units)
2013	81,382	1,451	114.33	0.99
2019	85,888	2,077	119.41	1.67
2020	86,938	2,089	120.51	1.69
2025	92,037	2,027	125.82	1.70
2030	96,380	1,987	131.09	1.66
2035	100,920	2,302	136.04	1.62
2040	106,649	2,408	140.96	1.62
2045	112,186	2,651	146.22	1.73
2048	115,646	2,808	149.48	1.77

Source: EIA *AEO 2015*.

The final component in the stock accounting model is shifts to or away from particular equipment classes. Based on the historic data, there is an apparent shift toward electric storage water heaters. The historical shipments summarized in Table IV.30 showed a fairly steady growth in commercial electric storage water heaters, with shipments growing from 22,288 in 1994 to 69,160 in 2013. 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, and to the higher value of 88,539 in 2013. Thus, there is an apparent shift away from gas-fired storage units, and because residential-

[86] United Nations, Department of Economic and Social Affairs Statistics Division, Trade Statistics, UN Comtrade—data extraction interface (Available at: *http://comtrade.un.org/data/*) (Last accessed April 1, 2015).

[87] Navigant, *Energy Savings Potential and RD&D Opportunities for Commercial Building Appliances.* 2009. Prepared for the U.S. Department of Energy, Energy Efficiency and Renewable Energy, Building Technologies Program (Available at: *http://apps1.eere.energy.gov/buildings/publications/pdfs/corporate/commercial_appliances_report_12-09.pdf*).

[88] Energy Information Administration (EIA), *2003 Commercial Building Energy Consumption Survey (CBECS) Data* (2003) (Available at: *http://www.eia.gov/consumption/commercial/data/2003/*).

[89] U.S. Energy Information Administration (EIA), *2015 Annual Energy Outlook* (2015) Full report. DOE/EIA–0383 (2014) (Available at: *http://www.eia.gov/forecasts/aeo/*).

duty gas-fired storage water heaters and gas-fired hot water supply boiler shipments were linked to gas-fired storage units, there is an apparent shift away from the residential-duty and hot water supply boiler equipment classes as well in the shipments analysis. These apparent shifts were developed for each equipment class and are captured in DOE's shipments model. The development of the apparent shifts and the effect on projected equipment class shipments is detailed in Chapter 7 of the TSD.

For each equipment class, there are factors that influence the magnitude of the apparent shifts, including relative fuel prices and the resultant energy cost of competing products, relative equipment and installation costs, repair and maintenance costs, commercial consumer preferences, and outside influences such as ENERGY STAR and utility conservation or marketing programs. If the slope of the apparent shifts in shipments is held constant at the values developed for 2013, the last year of historical data, over the study period commercial gas-fired storage water heater shipments would continue to decline, falling to 79,000 units by 2048, while over the same time period the commercial electric storage water heater shipments would climb to over 200,000 units. Nothing in the long term historical data indicates that such a wide disparity between gas-fired and electric storage water heater equipment shipments would develop. The historical data summarized in Table IV.30 show the growth rate in commercial gas-fired storage water heater equipment shipments over time to be flat, or increasing if one looks at the last 5 years. Rather than showing shifts that result in the wide disparity between commercial gas-fired and electric storage units, for the NOPR analyses DOE used a shift value equal to the 2013 shift values adjusted downward by 50 percent. The resulting shipment projection continues the observed trends of electric storage water heater shipments increasing over time at a rate faster than the commercial gas-fired water heater equipment. The resulting projection shows commercial electric storage water heater shipments exceeding commercial gas-fired storage shipments by 2030. The commercial electric storage water heater shipments exceed commercial gas-fired storage water heater shipments by approximately 25 percent in final year of the study period (2048).

For all equipment classes, DOE assumed that the apparent shift is most likely to occur in new installations rather than in the replacement installations. As described in chapter 9 of the 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 2014, 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 multiplied 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.

The resulting shipment projection is shown in Table IV.32.

TABLE IV.32—SHIPMENTS OF COMMERCIAL WATER HEATING EQUIPMENT

Year	Commercial gas-fired storage water heaters	Residential-duty gas-fired storage water heaters	Gas-fired tankless water heaters	Gas-fired hot water supply boilers	Electric storage water heaters
2013	88,539	18,086	9,838	15,858	69,160
2019	95,145	19,534	8,940	21,959	86,782
2020	92,054	19,402	11,128	22,060	89,390
2025	102,269	19,243	13,323	21,969	91,501
2030	103,025	21,590	14,957	21,957	105,626
2035	109,539	20,911	14,606	22,383	121,567
2040	115,788	22,647	22,817	26,637	131,683
2045	121,163	23,725	22,625	31,671	153,854
2048	130,779	23,726	24,170	32,951	164,934

Because the estimated energy usage of CWH equipment differs by commercial and residential setting, the NIA employs the same fractions of shipments (or sales) to commercial and to residential commercial consumers used by the LCC analysis. The fractions of shipments by type of commercial consumer are shown in Table IV.33.

TABLE IV.33—SHIPMENT SHARES BY TYPE OF COMMERCIAL CONSUMER

Equipment class	Commercial (%)	Residential (%)
Commercial gas-fired storage water heaters and gas-fired storage-type instantaneous water heaters	81.0	19.0
Residential-duty gas-fired storage water heaters	48.0	52.0
Gas-fired instantaneous water heaters and hot water supply boilers:		
Gas-fired tankless water heaters	67.0	33.0
Gas-fired hot water supply boilers	82.0	18.0
Electric storage water heaters	77.0	23.0

Issue 25: DOE seeks input on actual historical shipments for the three equipment classes for which no historical shipments data exist—residential-duty gas-fired storage water heaters, gas-fired tankless water heaters, and gas-fired hot water supply boilers.

Issue 26: DOE seeks input on the methodology used to estimate the historical shipments for the residential-duty gas-fired storage water heater, gas-fired tankless water heater, and hot water supply boiler equipment classes, particularly in the absence of actual historic shipments data.

Issue 27: DOE seeks input on commercial consumer switching between equipment types or fuel types, and specific information that DOE can use to model such commercial consumer switching. For example, if a commercial consumer switches away from commercial gas-fired storage water heaters, to what type of equipment is the commercial consumer most likely to switch, and is it a one-for-one switch or some other ratio?

Issue 28: DOE seeks input on the shares of shipments allocated to commercial and to residential consumer types.

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 compiled and analyzed a database of equipment currently produced and sold by manufacturers. The sources of information for this database included the AHRI Certification Directory,[90] the California Energy Commission Appliance Efficiency Database,[91] and manufacturer catalogs and Web sites. DOE recognizes that demand varies across different models of equipment, and that by relying on the database of existing equipment DOE is explicitly assuming each model of equipment is equally likely to be shipped for sale to commercial consumers. Lacking data to the contrary, DOE determined that the distribution of shipments by efficiency level derived from available equipment models is a reasonable approximation of the distribution that would be derived from actual equipment shipments.

Pursuant to DOE's October 2014 RFI, stakeholders commented on inputs to the shipment analysis and offered support. AHRI mentioned that it was consulting with its members to develop information that addressed efficiency market shares of shipments and would provide the findings to DOE once they were collated. (AHRI, No. 5 at p. 6) Rheem stated that over the last 3 years, the shipments mix had increased towards high-efficiency gas-fired condensing water heaters. (Rheem, No. 10 at p. 8) Bradford White stated that it would work with AHRI to respond on current and historical efficiency shares of shipments. (Bradford White, No. 3 at p. 3) DOE appreciates the offer of assistance from AHRI and manufacturers. DOE notes that this information was not received (or at least, not received in time for use in this NOPR), but DOE remains hopeful that AHRI and manufacturers can provide information on shipments, generally, and on shipment efficiency distributions for use in the next phase of this rulemaking.

Rheem stated that the percentage of commercial water heaters used in single-family residential-duty applications is minimal. (Rheem, No. 10 at p. 6) DOE's LCC analysis estimated the fraction of each equipment type that is applied to residential or commercial building types. For the shipment analysis, the distinction between single-family and multifamily construction would have a second-order impact on the estimates of shipments. DOE uses the building stock estimates to derive annual saturation rates, which are then applied to estimated new construction. For the NOPR, DOE used total residential building stocks. If DOE used only multifamily stocks, the saturation rates would be higher, but the stock against which it is applied would be smaller, so from a mathematical perspective, the results would be similar. The main difference would derive from the fact that multifamily construction would be projected to grow at different rates by EIA than would total residential construction. Over the 30-year analysis period, total residential stock grows at 1.0 percent while multifamily stock grows at 0.8 percent.

Issue 29: DOE seeks input on whether the shipment model should assume that multifamily buildings are the only residential building stock in which CWH equipment is used, or whether DOE should continue to use total residential building stocks.

In terms of evaluating shipment growth, DOE used the projected number of millions of square feet of floor space additions and new residential construction to drive the new additions forecast. A number of the topics discussed in the Joint Advocates comment, such as the impact of increased equipment height or diameter on the ease with which the equipment can physically be carried into a building, were considered in the estimation of installation costs in the LCC analysis.

H. National Impact Analysis

The national impact analysis (NIA) analyzes the effects of a potential energy conservation standard from a national perspective. The NIA assesses the NES and the NPV of total commercial consumer costs and savings that would be expected to result from the amended standards. The NES and NPV are analyzed at specific efficiency levels (*i.e.,* TSLs) for each equipment class of CWH equipment. DOE calculates the NES and NPV based on projections of annual equipment shipments, along with the annual energy consumption and total installed cost data from the LCC analysis. For the NOPR analysis, DOE forecasted the energy savings, operating cost savings, equipment costs, and NPV of commercial consumer benefits for equipment shipped from 2019 through 2048—the year in which the last standards-compliant equipment would be shipped during the 30-year analysis period.

DOE evaluates the impacts of the new and amended standards by comparing no-new-standards-case projections with standards-case projections. The no-new-standards-case projections characterize energy use and commercial consumer costs for each equipment class in the absence of any new or amended energy conservation standards. DOE compares these no-new-standards-case projections with projections characterizing the market for each equipment class if DOE adopted the amended standards at each TSL. For the standards cases, DOE assumed a ''roll-up'' scenario in which equipment at efficiency levels that do not meet the standard level under consideration would ''roll up'' to the efficiency level that just meets the proposed standard level, and equipment already being purchased at efficiency levels at or above the proposed standard level would remain unaffected.

DOE uses a computer spreadsheet model to calculate the energy savings and the national commercial consumer costs and savings from each TSL. Chapter 10 and appendix 10A of the NOPR TSD explain the models and how to use them, and interested parties can review DOE's analyses by interacting with these spreadsheets. The models and documentation are available on DOE's Web site.[92] Interested parties can review DOE's analyses by changing various input quantities within the spreadsheet.

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

[90] AHRI Certification Directory is available at: *https://www.ahridirectory.org/ahridirectory/pages/home.aspx.*

[91] California Energy Commission Appliance Efficiency Database is available at: *https://cacertappliances.energy.ca.gov/Pages/ApplianceSearch.aspx.*

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

projections of energy prices and building stock and additions from the *AEO 2015* Reference case. Additionally, DOE analyzed scenarios that used inputs from the *AEO 2015* Low Economic Growth and High Economic Growth cases. These cases have lower and higher energy price trends, respectively, compared to the Reference case. NIA results based on these cases are presented in chapter 10 of the NOPR TSD.

A detailed description of the procedure to calculate NES and NPV and inputs for this analysis are provided in chapter 10 of the NOPR TSD.

1. Equipment Efficiency in the No-New-Standards Case and 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 amended standards. 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 [93] of equipment currently available. DOE applied the percentages of models within each efficiency range to the total unit shipments for a given equipment class to estimate the distribution of shipments for the no-new-standards case. Then, from those market shares and projections of shipments by equipment class, DOE extrapolated future equipment efficiency trends both for a no-new-standards-case scenario and for standards-case scenarios.

This rulemaking is examining potential improvements for both thermal efficiency of equipment and in the standby energy usage. Thus, two sets of efficiency distributions for the no-new standards-case scenario were developed for these classes. Table IV.34 shows the distribution of equipment by thermal efficiency level. The standby loss efficiency distribution is summarized in Table IV.35.

TABLE IV.34—MARKET SHARES BY THERMAL EFFICIENCY LEVEL *

Equipment class	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 gas-fired storage-type instantaneous water heaters	57	12	0	6	23	1
Residential-duty gas-fired storage water heaters	66	9	3	16	6	
Gas-fired instantaneous water heaters and hot water supply boilers:						
Gas-fired tankless water heaters	16	40	28	4	4	8
Gas-fired hot water supply boilers	40	24	14	2	7	13
Electric storage water heaters	100					

* Due to rounding, shares for each equipment class might not add to 100 percent.
** E_t EL refers to Thermal Efficiency Level.

TABLE IV.35—MARKET SHARES BY STANDBY LOSS EFFICIENCY LEVEL

Equipment class	Standby loss level **	E_t EL0 * %	E_t EL1 (%)	E_t EL2 (%)	E_t EL3 (%)	E_t EL4 (%)	E_t EL5 (%)
Commercial gas-fired Storage and storage-type instantaneous water heaters.	SL EL0	76	88	0	67	33	75
	SL EL1	20	0	0	19	14	25
	SL EL2	4	13	100	14	53	0
Residential-duty gas-fired storage water heaters.	SL EL0	82	17	0	0	0	
	SL EL1	11	0	100	100	100	
	SL EL2	5	17	0	0	0	
	SL EL3	2	67	0	0	0	
Electric storage water heaters.	SL EL1	97					
	SL EL2	3					

* E_t EL refers to Thermal Efficiency Level.
** SL EL refers to Standby Loss Efficiency Level.

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 amended standards. The analysis starts with the no-new-standards-case distributions wherein shipments are assumed to be distributed across thermal efficiency levels as shown in Table IV.34. 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 thermal efficiency standard level being considered would roll up to meet the amended standard level. This information also suggests that equipment efficiencies in the no-new-standards case that were above the standard level under consideration would not be affected.

For the equipment classes for which standby loss standards are being considered, the analysis takes into account a two-dimensional rollup. Equipment is distributed across the thermal efficiency levels, and for 3 classes, across the SL efficiency levels. Thus, in the analysis, a second roll-up

[93] This database was developed using model data from the AHRI Certification Directory (available at: *https://www.ahridirectory.org/ahridirectory/pages/home.aspx*), California Energy Commission Appliance Efficiency Database (available at: *https://cacertappliances.energy.ca.gov/Pages/ApplianceSearch.aspx*), and manufacturer Web sites and catalogs.

occurs starting with equipment distributed across SL efficiency levels as shown in Table IV.35. As higher SL levels are considered, equipment not meeting the standard being considered would roll-up to the SL level being considered. The no-new-standards-case efficiency distributions for each equipment class are discussed more fully in chapter 10 of the NOPR TSD.

2. National Energy Savings

The inputs for determining the NES are: (1) Annual energy consumption per unit; (2) shipments; (3) equipment stock; and (4) site-to-source and full-fuel-cycle conversion factors.

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 commercial water heating equipment stock gradually decreases in the standards case relative to the no-new-standards case as more-efficient commercial water heating units gradually replaces less-efficient units.

Unit energy consumption values for each equipment class are taken from the LCC spreadsheet for each efficiency level and weighted based on market efficiency distributions. To estimate the total energy savings for each efficiency level, DOE first calculated the per-unit energy reduction (*i.e.,* the difference between the energy directly consumed by a unit of equipment in operation in the no-new-standards case and the standards case) for each class of commercial water heating equipment for each year of the analysis period. The analysis period begins with the expected compliance date of amended energy conservation standards (*i.e.,* 2019, or 3 years after the publication of a final rule issued as a result of this rulemaking). Second, DOE determined the annual site energy savings by multiplying the stock of each equipment class by vintage (*i.e.,* year of shipment) by the per-unit energy reduction for each vintage (from step one). 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 National Energy Modeling System (NEMS). 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 commercial water heating equipment in this rulemaking.

DOE has historically presented NES in terms of primary energy savings. In the case of electricity use and savings, primary energy savings include the energy lost in the power system in the form of losses as well as the energy input required at the electric generation station in order to convert and deliver the energy required at the site of consumption. DOE uses a multiplicative factor called the ''site-to-source conversion factor'' to convert site energy consumption to primary energy consumption.

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 full-fuel-cycle (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). While DOE stated in that notice that it intended to use the Greenhouse Gases, Regulated Emissions, and Energy Use in Transportation (GREET) model to conduct the analysis, it also said it would review alternative methods, including the use of NEMS. After evaluating both models and the approaches discussed in the August 18, 2011 notice, DOE published a statement of amended policy in the **Federal Register** in which DOE explained its determination that NEMS is a more appropriate tool for its FFC analysis and its intention to use NEMS for that purpose. 77 FR 49701 (August 17, 2012). DOE received one comment, which was supportive of the use of NEMS for DOE's FFC analysis.[94]

The approach used for this NOPR, the site-to-source ratios, and the FFC multipliers that were applied are described in appendix 10D of the NOPR TSD. NES results are presented in both primary and FFC savings in section V.B.3.a.

DOE considered whether a rebound effect is applicable in its NES analysis for commercial water heating equipment. A rebound effect occurs when an increase in equipment efficiency leads to increased demand for its service. For example, when a commercial 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, for example, by taking longer showers and thereby consuming more hot water. In this way, the commercial 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 that are the subject of this notice are 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, DOE believes 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 (October 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 won't 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) Based on its understanding of CWH equipment use as well as comments received from stakeholders, DOE concurs that the likelihood of a rebound effect is small and has not included a rebound effect in the analysis.

American Gas Association suggested that DOE use full-fuel-cycle measurements in its analysis. (AGA, No. 4 at p. 2) DOE agrees with the suggestion.

Issue 30: DOE seeks input on the possibility that rebound effect would be

[94] Docket ID: EERE–2010–BT–NOA–0028, comment by Kirk Lundblade.

significant, and if so, estimates of the impact of the rebound effect on NES.

3. Net Present Value

To estimate the NPV, DOE calculated the net impact as the difference between total operating cost savings and increases in total installed costs. DOE calculated the NPV of each considered standard level over the life of the equipment using the following three steps.

First, DOE determined the difference between the equipment costs under the standard-level 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, DOE used a constant real price assumption as the default price projection; the cost to manufacture a given unit of higher efficiency neither increases nor decreases over time. The analysis of the price trends is described in appendix 10B of the NOPR TSD.

Second, DOE determined the difference between the no-new-standards-case operating costs and the standard-level operating costs in order to obtain the net operating cost savings from each higher efficiency level. Third, DOE 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 2015 for CWH equipment bought on or after 2019 and summed the discounted values to provide the NPV for an efficiency level.

In accordance with the OMB's guidelines on regulatory analysis,[95] DOE calculated NPV using both a 7-percent and a 3-percent real discount rate. The 7-percent rate is an estimate of the average before-tax rate of return on private capital in the U.S. economy. DOE used this discount rate to approximate the opportunity cost of capital in the private sector, because recent OMB analysis has found the average rate of return on capital to be near this rate. DOE used the 3-percent rate to capture the potential effects of standards on private consumption (*e.g.,* through higher prices for products and reduced purchases of energy). This is the rate at which society discounts future consumption flows to their present value. This rate can be approximated by the real rate of return on long-term government debt (*i.e.,* yield on United States Treasury notes minus annual rate of change in the Consumer Price Index), which has averaged about 3 percent on a pre-tax basis for the past 30 years.

American Gas Association recommended that DOE include a fuel switching analysis to ensure that standards would not result in switching to less-efficient energy sources. (AGA, No. 4 at p. 2) As part of the analysis, DOE examined the possibility of fuel switching by using NIA inputs to examine commercial consumer payback periods in situations where commercial consumers switch from gas-fired to electric water heaters. In an attempt to make the values comparable, DOE adjusted values using ratios based on the first-hour ratings shown in Table IV.36. In the case of moving from a commercial gas-fired to an electric storage water heater, the electric water heater would cost more to purchase and install and cost more to operate. In the comparison of residential-duty gas-fired to electric storage water heaters, the electric water heater would be less expensive to purchase and install, but sufficiently more expensive to operate, such that the upfront cost savings would be outweighed by higher operating costs in 3 years. Based on the comparison of storage water heating equipment, DOE does not believe fuel switching from gas to electricity to be an issue.

TABLE IV.36—FIRST-HOUR EQUIPMENT RATINGS USED IN FUEL SWITCHING ANALYSIS

Year	Commercial gas-fired storage water heaters	Residential-duty gas-fired storage water heaters	Gas-fired tankless water heaters	Gas-fired 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. 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 in combination with the first-hour rating.

DOE did not consider instantaneous gas-fired equipment and electric storage 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. As the first-hour ratings indicate in Table IV.36, a commercial consumer would need to purchase between 2 and 4 electric storage water heaters to switch from instantaneous gas-fired equipment to the electric storage equipment. While feasible for commercial consumers not facing space constraints, DOE considered it unlikely that these consumers would chose to replace one wall-mounted tankless unit with two much larger floor-mounted electric storage water heaters. It also seemed unlikely that consumers would replace one hot water supply boiler with multiple electric storage water heaters.

Accordingly, for the NOPR, DOE did not explicitly include fuel switching beyond the continuation of historical trends discussed in section IV.G.

I. Commercial 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 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 commercial consumers at the lowest income bracket in the residential sector and only included them for the residential sector subgroup analysis. Additionally, DOE identified small

[95] Office of Management and Budget, section E in *OMB Circular A–4* (Sept. 17, 2003) (Available at: *www.whitehouse.gov/omb/circulars_a004_a-4).*

business groups in CBECS and only included those samples in the commercial sector subgroup analysis. The following provides further detail regarding DOE's consumer subgroup analysis.

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% income percentile), income bin 2 (20–40% income percentile), income bin 3 (40–60% income percentile), income bin 4 (60–80% income percentile), income bin 5 (80–90% income percentile), and income bin 6 (90–100% 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% income percentile samples were included for the entire simulation run. Subsequently, the results of the subgroup analysis are compared to the results from all commercial consumers.

Commercial Sector Subgroup Analysis: DOE identified small businesses within CBECS by using threshold levels in different building types. Threshold levels indicating maximum number of employees in each building type (such as Assembly, Education, Food Service, Office, Retail, and Warehouse) are used to identify small business within CBECS. Subsequently, in addition to the discount rate chosen for each ''small business'' sample, a premium of 1.9 percent is added to evaluate future benefit and cost streams.[96] A premium of 1.9 percentage points is added to each discounted rate by business type from the central LCC to reflect the appropriate discount costs for small business entities of that business type. This analytical setup reflects the fact that in general, smaller businesses tend to discount future streams of monetary flows at higher rates.

The results of DOE's LCC subgroup analysis for both subgroups are summarized in section V.B.1.b of this notice and described in detail in chapter 11 of the NOPR TSD.

J. Manufacturer Impact Analysis

1. Overview

DOE performed a manufacturer impact analysis (MIA) to determine the financial impact of amended energy conservation standards on manufacturers of CWH equipment and to estimate the potential impact of amended standards on employment and manufacturing capacity. The MIA has both quantitative and qualitative aspects. The quantitative part of the MIA primarily relies on the Government Regulatory Impact Model (GRIM), an industry cash-flow model with inputs specific to this rulemaking. The key GRIM inputs are industry cost structure data, shipment data, equipment costs, and assumptions about markups and conversion costs. The key output is the industry net present value (INPV). DOE used the GRIM to calculate cash flows using standard accounting principles and to compare changes in INPV between a no-new-standards case and various TSLs (the standards cases). The difference in INPV between the no-new-standards case and standards cases represents the financial impact of amended energy conservation standards on manufacturers of CWH equipment. DOE used different sets of assumptions (markup scenarios) to represent the uncertainty surrounding potential impacts on prices and manufacturer profitability as a result of amended standards. These different assumptions produce a range of INPV results. The qualitative part of the MIA addresses the proposed standard's potential impacts on manufacturing capacity and industry competition, as well as any differential impacts the proposed standard may have on any particular subgroup of manufacturers. The qualitative aspect of the analysis also addresses product characteristics, as well as any significant market or product trends. The complete MIA is outlined in chapter 12 of the NOPR TSD.

DOE conducted the MIA for this rulemaking in three phases. In the first phase of the MIA, DOE prepared an industry characterization based on the market and technology assessment, preliminary manufacturer interviews, and publicly-available information. As part of its profile of the CWH industry, DOE also conducted a top-down cost analysis of manufacturers in order to derive preliminary financial inputs for the GRIM (*e.g.,* sales, general, and administration (SG&A) expenses; research and development (R&D) expenses; and tax rates). DOE used public sources of information, including company SEC 10–K filings,[97] corporate annual reports, the U.S. Census Bureau's Economic Census,[98] and Hoover's reports [99] to conduct this analysis.

In the second phase of the MIA, DOE prepared an industry cash-flow analysis to quantify the potential impacts of amended energy conservation standards. In general, energy conservation standards can affect manufacturer cash flow in three distinct ways. These include: (1) Creating a need for increased investment; (2) raising production costs per unit; and (3) altering revenue due to higher per-unit prices and due to possible changes in sales volumes. DOE estimated industry cash flows in the GRIM at various potential standard levels using industry financial parameters derived in the first phase and the shipment scenario used in the NIA. DOE used the GRIM to model impacts from proposed energy conservation standards for both thermal efficiency and standby loss. The GRIM results for the standards for both metrics were analyzed together because the examined trial standard levels include both thermal efficiency and standby loss levels (see section V.A for more detail).

In the third phase of the MIA, DOE conducted structured, detailed interviews with a variety of manufacturers that represent approximately 88 percent of domestic sales of CWH equipment covered by this rulemaking. During these interviews, DOE discussed engineering, manufacturing, procurement, and financial topics to validate assumptions used in the GRIM. DOE also solicited information about manufacturers' views of the industry as a whole and their key concerns regarding this rulemaking. Section IV.J.3 includes a description of the key issues manufacturers raised during the interviews.

Additionally, in the third phase, DOE 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. For example, small manufacturers, niche players, or manufacturers exhibiting a cost structure that largely

[96] U.S. Small Business Administration, *The Small Business Economy* (Available at: *https://www.sba.gov/advocacy/small-business-economy*) (Last accessed May 26, 2015).

[97] U.S. Securities and Exchange Commission, Annual 10–K Reports (Various Years) (Available at: *http://www.sec.gov/edgar/searchedgar/companysearch.html*).

[98] U.S. Census Bureau, Annual Survey of Manufacturers: General Statistics: Statistics for Industry Groups and Industries (2011) (Available at: *http://factfinder2.census.gov/faces/nav/jsf/pages/searchresults.xhtml?refresh=t*).

[99] Hoovers Inc. Company Profiles, Various Companies (Available at: *http://www.hoovers.com*).

differs from the industry average could be more negatively affected by amended energy conservation standards. DOE identified one subgroup (small manufacturers) for a separate impact analysis.

To identify small businesses for this analysis, DOE applied the small business size standards published by the Small Business Administration (SBA) to determine whether a company is considered a small business. 65 FR 30836, 30848 (May 15, 2000), as amended at 77 FR 49991, 50000, 50011 (August 20, 2012) and codified at 13 CFR part 121. The small business size standards are listed by North American Industry Classification System (NAICS) code and industry description and are available at: *http://www.sba.gov/sites/default/files/files/Size_Standards_Table.pdf*. CWH manufacturing is classified under NAICS code 333318, ''Other Commercial and Service Industry Machinery Manufacturing.'' To be considered a small business under this category, a CWH equipment manufacturer may employ a maximum of 1,000 employees. This 1,000-employee threshold includes all employees in a business's parent company and any other subsidiaries. Based on this classification, DOE identified 13 manufacturers of CWH equipment that qualify as small businesses. The CWH small manufacturer subgroup is discussed in section VI.B of this NOPR and in chapter 12 of the NOPR TSD.

2. GRIM Analysis

DOE uses the GRIM to quantify the potential changes in cash flow due to amended standards that result in a higher or lower industry value. The GRIM is used to conduct an annual cash-flow analysis using standard accounting principles that incorporates manufacturer costs, markups, shipments, and industry financial information as inputs. DOE thereby calculated a series of annual cash flows, beginning in 2015 (the base year of the analysis) and continuing to 2048. DOE summed the stream of annual discounted cash flows during this period to calculate INPVs at each TSL. For CWH equipment manufacturers, DOE used a real discount rate of 9.1 percent, which was derived from industry financial information and then modified according to feedback received during manufacturer interviews. DOE also used the GRIM to model changes in costs, shipments, investments, and manufacturer margins that could result from amended energy conservation standards.

After calculating industry cash flows and INPV, DOE compared 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 at a particular TSL. As discussed previously, DOE collected this information on GRIM inputs from a number of sources, including publicly-available data and confidential interviews with a number of manufacturers. GRIM inputs are discussed in more detail in the next section. The GRIM results are discussed 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.

For consideration of amended standby loss standards, DOE modeled the impacts to manufacturers of adapting their currently-offered equipment to comply with each potential standby loss level analyzed in the engineering analysis. The GRIM analysis incorporates the incremental increases in MPC at each standby loss level and the resulting impacts on markups. Section IV.C.3 and chapter 5 of the NOPR TSD include further discussion of efficiency levels and equipment classes analyzed.

a. Government Regulatory Impact Model Key Inputs

Manufacturer Production Costs

Manufacturing higher-efficiency equipment is typically more expensive than manufacturing baseline equipment due to the use of more complex and costly components. The changes in the MPCs of the analyzed equipment can affect the revenues, gross margins, and cash flow of the industry. As a result, MPCs are key GRIM inputs for DOE's analysis.

In the MIA, DOE used the MPCs for each considered efficiency level calculated in the engineering analysis, as described in section IV.C and further detailed in chapter 5 of the NOPR TSD. In addition, DOE used information from its teardown analysis (described in chapter 5 of the TSD) to disaggregate the MPCs into material, labor, depreciation, and overhead costs. To calculate the MPCs for equipment at and above the baseline, DOE performed teardowns and cost analysis that allowed DOE to estimate the incremental material, labor, depreciation, and overhead costs for equipment above the baseline. These cost breakdowns and equipment markups were validated and revised with input from manufacturers during manufacturer interviews.

Shipments Forecast

The GRIM estimates manufacturer revenues based on total unit shipment forecasts and the distribution of these values 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 forecasts derived from the shipments analysis from 2015 (the base year) to 2048 (the end year of the analysis period). The shipments model divides the shipments of CWH equipment into specific market segments. The model starts from a historical base year and calculates retirements and shipments by market segment for each year of the analysis period. This approach produces an estimate of the total equipment stock, broken down by age or vintage, in each year of the analysis period. In addition, the equipment stock efficiency distribution is calculated for the no-new-standards case and for each standards case for each equipment class. The NIA shipments forecasts are based on a roll-up scenario. The forecast assumes that equipment in the no-new-standards case that does not meet the standard under consideration would ''roll up'' to meet the amended standard beginning in the compliance year of 2019. Section IV.G and chapter 9 of the NOPR TSD include additional details on the shipments analysis.

Product and Capital Conversion Costs

Amended energy conservation standards would cause manufacturers to incur one-time 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 for each equipment class. For the MIA, DOE classified these conversion costs into two major groups: (1) Capital conversion costs; and (2) product conversion costs. Capital conversion costs are one-time investments in property, plant, and equipment necessary to adapt or change existing production facilities such that new compliant equipment designs can be fabricated and assembled. Product conversion costs are one-time investments in research, development, testing, marketing, and other non-capitalized costs necessary to make equipment designs comply with amended energy conservation standards.

To develop conversion cost estimates, DOE used feedback received during manufacturer interviews, as well as data on manufacturing and equipment development costs derived from the equipment teardowns and engineering analysis discussed in chapter 5 of the NOPR TSD. DOE estimated conversion costs required to meet higher thermal efficiency levels for each equipment class and also evaluated conversion costs required to achieve higher standby loss levels, where applicable.

To evaluate the level of capital conversion expenditures manufacturers would likely incur to comply with amended thermal efficiency levels, DOE used data derived from the engineering analysis and equipment teardowns. DOE used these analyses to estimate investments in property, plant, and equipment that would be necessary to achieve higher thermal efficiency levels. DOE also used results from the engineering analysis to estimate capital expenditures manufacturers may have to make to upgrade their R&D and testing facilities.

To evaluate the level of product conversion costs manufacturers would likely incur to comply with amended thermal efficiency standards, DOE estimated the number of platforms each manufacturer would have to modify in order to move their equipment lines to each incremental efficiency level. These platform number estimates were based on the variation of units by input capacity offered by each manufacturer. DOE then developed the product conversion costs by estimating the amount of labor per platform manufacturers would need for research and development to raise models to each incremental efficiency level.

To evaluate the level of conversion costs manufacturers would likely incur to comply with amended standby loss standards, DOE used feedback received during manufacturer interviews, as well as data derived from the engineering analysis. For both commercial gas-fired storage water heaters and electric storage water heaters, DOE estimated that manufacturers would incur approximately $1.1 million in capital conversion costs at all standby loss levels above the baseline. For residential-duty gas-fired storage water heaters, DOE did not include capital conversion costs at the analyzed standby loss levels, because DOE has tentatively concluded that manufacturers already possess the machinery and tooling necessary to achieve those levels as part of their current production capabilities for either residential water heaters or residential-duty commercial water heaters. DOE does not expect manufacturers to incur any product conversion costs related to amended standby loss standards, because DOE expects no substantial redesign work or research and development would be necessary to achieve the standby loss levels analyzed in the engineering analysis. Section IV.C.3.b of this NOPR and Chapter 5 of the NOPR TSD include additional details on the efficiency levels analyzed in the engineering analysis.

Issue 31: DOE requests comment on whether manufacturers would incur any product conversion costs (*i.e.,* substantial redesign work or research and development) related to the standby loss levels analyzed in this NOPR.

In general, DOE assumes that all conversion-related investments occur between the year of publication of the final rule and the year by which manufacturers must comply with the amended standards. The conversion cost figures used in the GRIM can be found in section V.B.2 of this notice. For additional information on the estimated product and capital conversion costs, see chapter 12 of the NOPR TSD.

b. Government Regulatory Impact Model Scenarios

Markup Scenarios

As discussed in the previous section, MSPs include direct manufacturing production costs (*i.e.,* labor, materials, depreciation, and overhead estimated in DOE's MPCs) and all non-production costs (*i.e.,* SG&A, R&D, and interest), along with profit. To calculate the MSPs in the GRIM, DOE applied non-production cost markups to the MPCs estimated in the engineering analysis for each equipment class and efficiency level. Specifically, the manufacturer markup is a multiplier that is applied to the MPC. The MSP is calculated by adding the shipping cost to the product of the MPC and manufacturer markup. Modifying these markups in the standards case yields different sets of impacts on manufacturers. For the MIA, DOE modeled two standards-case markup scenarios to represent the uncertainty regarding the potential impacts on prices and profitability for manufacturers following the implementation of amended energy conservation standards: (1) A preservation of gross margin percentage markup scenario; and (2) a preservation of per-unit operating profit markup scenario. These scenarios lead to different markup values that, when applied to the inputted MPCs, result in varying revenue and cash-flow impacts.

Under the preservation of gross margin percentage markup scenario, DOE applied a single uniform ''gross margin percentage'' markup across all efficiency levels, which assumes that following amended standards, manufacturers would be able to maintain the same amount of profit as a percentage of revenue at all efficiency levels within an equipment class. As production costs increase with efficiency, this scenario implies that the absolute dollar markup will increase as well. Because manufacturers are able to fully pass through additional costs due to standards to commercial consumers, the preservation of gross margin percentage markup scenario represents the upper bound of the CWH industry's profitability in the standards case.

To estimate the average non-production cost 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.37. These markups capture all non-production costs, including SG&A expenses, R&D expenses, interest expenses, and profit.

TABLE IV.37—MANUFACTURER MARKUPS BY EQUIPMENT CLASS FOR PRESERVATION OF GROSS MARGIN SCENARIO

Equipment class	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
Hot water supply boilers	1.43
Electric storage water heaters	1.41

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 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, as they are able to do in the preservation of gross margin percentage markup scenario.

3. Manufacturer Interviews

DOE interviewed manufacturers representing approximately 88 percent of the CWH market by revenue. DOE contractors endeavor to conduct interviews with a representative cross-section of manufacturers (including large and small manufacturers, covering all equipment classes and product offerings). DOE contractors reached out to all the small business manufacturers that were identified as part of the analysis, as well as larger manufacturers that have significant market share in the CWH market. As part of these interviews, DOE gathered manufacturer feedback regarding both the engineering analysis and MIA for this rulemaking. The information gathered during these interviews enabled DOE to tailor the GRIM to reflect the unique financial characteristics of the CWH industry. All interviews provided information that DOE used to evaluate the impacts of potential amended energy conservation standards on manufacturer cash flows, manufacturing capacities, and employment levels.

In interviews, DOE asked manufacturers to describe their major concerns with potential standards arising from a rulemaking involving CWH equipment. Manufacturer interviews are conducted under non-disclosure agreements (NDAs), so DOE does not document these discussions in the same way that it does public comments in the comment summaries and DOE's responses throughout the rest of this notice. The following sections highlight the most significant of manufacturers' statements that helped shape DOE's understanding of potential impacts of an amended standard on the industry. Common issues raised by manufacturers in interviews included: the magnitude of conversion costs and the complexity and cost of retrofits.

Magnitude of Conversion Costs

Manufacturers stated in interviews that an increase in the stringency of energy conservation standards may cause them to face significant capital and product conversion costs to bring their equipment into compliance if DOE were to propose a standard that necessitates condensing technology. While all major CWH manufacturers currently produce condensing equipment, most also offer a wide range of non-condensing equipment that they stated is important in serving the replacement market. Manufacturers stated that eliminating non-condensing equipment would strand production assets and could result in manufacturers having to make capital investments in machinery and tooling to increase their condensing equipment production capacity.

Manufacturers also stated that shifting their entire product line to condensing equipment would require significant product conversion costs for R&D and testing. Most manufacturers currently offer a less diverse product line of condensing equipment, compared to their non-condensing equipment offerings. Several stated that in order to serve the replacement market and remain competitive, they would need to develop a range of sizes and capacities of condensing equipment that they currently only offer at non-condensing thermal efficiency levels. Manufacturers stated that this would require a substantial engineering effort.

Complexity and Cost of Retrofits

In interviews, several manufacturers pointed out that approximately 85 percent of CWH equipment sales are conducted in the replacement channel, rather than the new construction channel. They stated that the majority of the CWH market is structured around the legacy venting infrastructure designed for non-condensing equipment. Manufacturers stated that these venting systems are not designed to handle the acidic condensate that develops in condensing equipment. Manufacturers were concerned that commercial consumers would have to make expensive retrofits to install condensing products. According to manufacturers, this may result in commercial consumers repairing water heaters, rather than replacing them, which manufacturers argued would not save energy.

Impacts on Innovation

Manufacturers expressed concern that more-stringent energy conservation standards may stifle innovation in the industry by causing manufacturers to spend funds set aside for product innovation on compliance efforts instead. Several manufacturers pointed out that it is important for them to continually develop unique and innovative products in order to differentiate their brands in the market. They pointed out that it is difficult to accomplish this when engineering resources are diverted to focus on compliance with amended DOE standards. Manufacturers stated that this concern is particularly important for small manufacturers' ability to compete in the market. Small manufacturers generally have fewer resources to devote to compliance, and so may be at a disadvantage if DOE amends energy conservation standards.

K. Emission 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 all species due to ''upstream'' activities in the fuel production chain. These upstream activities comprise extraction, processing, and transporting fuels to the site of combustion. The associated emissions are referred to as upstream emissions.

The analysis of power sector emissions uses marginal emissions factors calculated using a methodology based on results published for the *AEO 2015* Reference case and a set of side cases that implement a variety of efficiency-related policies. The methodology is described in chapter 15 of the NOPR TSD.

Combustion emissions of CH_4 and N_2O are estimated using emissions intensity factors published by the EPA, GHG Emissions Factors Hub.[100] 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 fuel combustion during extraction, processing, and transportation of fuel, and ''fugitive'' emissions (direct leakage to the atmosphere) of CH_4 and CO_2.

The emissions intensity factors are expressed in terms of physical units per MWh or MMBtu of site energy savings. Total emissions reductions are estimated using the energy savings calculated in the national impact analysis.

For CH_4 and N_2O, DOE calculated emissions reduction in tons and also in terms of units of carbon dioxide equivalent (CO_2eq). Gases are converted to CO_2eq by multiplying the physical units by the gas's global warming potential (GWP) over a 100-year time horizon. Based on the Fifth Assessment Report of the Intergovernmental Panel on Climate Change,[101] DOE used GWP values of 28 for CH_4 and 265 for N_2O.

Because the on-site operation of some CWH equipment requires use of fossil fuels and results in emissions of CO_2, NO_X, and SO_2 at the sites where these appliances are used, DOE also accounted for the reduction in these site emissions and the associated upstream emissions due to potential standards. Site emissions were estimated using emissions intensity factors from an EPA publication.[102]

The *AEO* incorporates the projected impacts of existing air quality regulations on emissions. *AEO 2015* generally represents current legislation and environmental regulations, including recent government actions, for which implementing regulations were available as of October 31, 2014. DOE's estimation of impacts accounts for the presence of the emissions control programs discussed in the following paragraphs.

SO_2 emissions from affected electric generating units (EGUs) are subject to nationwide and regional emissions cap-and-trade programs. Title IV of the Clean Air Act sets an annual emissions cap on SO_2 for affected EGUs in the 48 contiguous States and the District of Columbia (DC). (42 U.S.C. 7651 *et seq.*) SO_2 emissions from 28 eastern States and DC were also limited under the Clean Air Interstate Rule (CAIR). 70 FR 25162 (May 12, 2005). CAIR created an allowance-based trading program that operates along with the Title IV program. In 2008, CAIR was remanded to EPA by the U.S. Court of Appeals for the District of Columbia Circuit, but it remained in effect.[103] In 2011, EPA issued a replacement for CAIR, the Cross-State Air Pollution Rule (CSAPR). 76 FR 48208 (August 8, 2011). On August 21, 2012, the DC Circuit issued a decision to vacate CSAPR,[104] and the court ordered EPA to continue administering CAIR. On April 29, 2014, the U.S. Supreme Court reversed the judgment of the DC Circuit and remanded the case for further proceedings consistent with the Supreme Court's opinion.[105] On October 23, 2014, the DC Circuit lifted the stay of CSAPR.[106] Pursuant to this action, CSAPR went into effect (and CAIR ceased to be in effect) as of January 1, 2015. On July 28, 2015, the DC Circuit issued its opinion regarding CSAPR on remand from the Supreme Court. The court largely upheld CSAPR, but remanded to EPA without vacatur certain States' emissions budgets for reconsideration.[107]

EIA was not able to incorporate CSAPR into *AEO 2015,* so it assumes implementation of CAIR. Accordingly, DOE's analysis used emissions factors that assume that CAIR, not CSAPR, is the regulation in force. However, the difference between CAIR and CSAPR is not significant for the purpose of DOE's analysis of emissions impacts from energy conservation standards.

The attainment of emissions caps is typically flexible among EGUs and is enforced through the use of emissions allowances and tradable permits. 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 any regulated EGU. In past rulemakings, DOE recognized that there was uncertainty about the effects of efficiency standards on SO_2 emissions covered by the existing cap-and-trade system, but it concluded that negligible reductions in power sector SO_2 emissions would occur as a result of standards.

Beginning around 2016, however, SO_2 emissions will fall as a result of the Mercury and Air Toxics Standards (MATS) for power plants.[108] 77 FR 9304 (Feb. 16, 2012). In the final MATS 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 will be reduced as a result of the control technologies installed on coal-fired power plants to comply with the MATS requirements for acid gas. *AEO 2015* assumes that, in order to continue operating, coal plants must have either flue gas desulfurization or dry sorbent injection systems installed by 2016. Both technologies, which are used to reduce acid gas emissions, also reduce SO_2 emissions. Under the MATS, emissions will be far below the cap that would be established by CAIR, so it is unlikely that excess SO_2 emissions allowances resulting from the lower electricity

[100] Available at: *http://www.epa.gov/climateleadership/inventory/ghg-emissions.html.*

[101] IPCC (2013): *Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change* [Stocker, T.F., D. Qin, G.-K. Plattner, M. Tignor, S.K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex and P.M. Midgley (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA. Chapter 8.

[102] U.S. Environmental Protection Agency, Compilation of Air Pollutant Emission Factors, AP–42, Fifth Edition, Volume I: Stationary Point and Area Sources (1998) (Available at: *http://www.epa.gov/ttn/chief/ap42/index.html*).

[103] See *North Carolina* v. *EPA,* 550 F.3d 1176 (D.C. Cir. 2008); *North Carolina* v. *EPA,* 531 F.3d 896 (D.C. Cir. 2008).

[104] See *EME Homer City Generation, LP* v. *EPA,* 696 F.3d 7, 38 (D.C. Cir. 2012), *cert. granted,* 81 U.S.L.W. 3567, 81 U.S.L.W. 3696, 81 U.S.L.W. 3702 (U.S. June 24, 2013) (No. 12–1182).

[105] *EPA* v. *EME Homer City Generation,* 134 S.Ct. 1584, 1610 (U.S. 2014). The Supreme Court held in part that EPA's methodology for quantifying emissions that must be eliminated in certain States due to their impacts in other downwind States was based on a permissible, workable, and equitable interpretation of the Clean Air Act provision that provides statutory authority for CSAPR.

[106] *EME Homer City Generation* v. *EPA,* Order (D. C. Cir. filed October 23, 2014) (No. 11–1302).

[107] *EME Homer City Generation, LP* v. *EPA 795 F.3d 118 (D.C. Cir. 2015).*

[108] DOE notes that on June 29, 2015, the U.S. Supreme Court ruled that the EPA erred when the agency concluded that cost did not need to be considered in the finding that regulation of hazardous air pollutants from coal- and oil-fired electric utility steam generating units is appropriate and necessary. Michigan v. Environmental Protection Agency, 576 U.S. ___ (2015). The Supreme Court did not vacate the MATS rule, and DOE has tentatively determined that the Court's decision on the MATS rule does not change the assumptions regarding the impact of energy conservation standards on SO_2 emissions (see chapter 13 of the NOPR TSD for further discussion). Further, the Court's decision does not change the impact of the energy conservation standards on mercury emissions. The EPA, in response to the U.S. Supreme Court's direction, has now considered cost in the appropriate and necessary finding. On November 20, 2015, the EPA proposed a supplemental finding that including a consideration of cost does not alter the EPA's previous determination that it is appropriate to regulate air toxics, including mercury, from power plants.

demand would be needed or used to permit offsetting increases in SO_2 emissions by any regulated EGU. Therefore, DOE believes that energy conservation standards will reduce SO_2 emissions in 2016 and beyond.

CAIR established a cap on NO_X emissions in 28 eastern States and the District of Columbia.[109] Energy conservation standards are expected to have little effect on NO_X emissions in those States covered by CAIR because excess NO_X emissions allowances resulting from the lower electricity demand could be used to permit offsetting increases in NO_X emissions from other facilities. However, standards would be expected to reduce NO_X emissions in the States not affected by the caps, so DOE estimated NO_X emissions reductions from the standards considered in this NOPR for these States.

The MATS limit mercury emissions from power plants, but they do not include emissions caps, and as such, DOE's energy conservation standards would likely reduce Hg emissions. DOE estimated mercury emissions reduction using emissions factors based on *AEO 2015,* which incorporates MATS.

L. Monetizing Carbon Dioxide and Other Emissions Impacts

As part of the development of this NOPR, DOE considered the estimated monetary benefits from the reduced emissions of CO_2 and NO_X that are expected to result from each of the TSLs considered. In order to make this calculation similar to the calculation of the NPV of commercial consumer benefit, DOE considered the reduced emissions expected to result over the lifetime of equipment shipped in the forecast period for each TSL. This section summarizes the basis for the monetary values used for CO_2 and NO_X emissions and presents the values considered in this NOPR.

For this NOPR, DOE is relying on a set of values for the social cost of carbon (SCC) that was developed by an interagency process. A summary of the basis for those values is provided in the following subsection, and a more detailed description of the methodologies used is provided as an appendix to chapter 14 of the NOPR TSD.

[109] CSAPR also applies to NO_X, and it would supersede the regulation of NO_X under CAIR. As stated previously, the current analysis assumes that CAIR, not CSAPR, is the regulation in force. The difference between CAIR and CSAPR with regard to DOE's analysis of NO_X emissions is slight.

1. Social Cost of Carbon

The SCC is an estimate of the monetized damages associated with an incremental increase in carbon emissions in a given year. It is intended to include (but is not limited to) changes in net agricultural productivity, human health, property damages from increased flood risk, and the value of ecosystem services. Estimates of the SCC are provided in dollars per metric ton of carbon dioxide. A domestic SCC value is meant to reflect the value of damages in the United States resulting from a unit change in carbon dioxide emissions, while a global SCC value is meant to reflect the value of damages worldwide.

Under section 1(b)(6) of Executive Order 12866, ''Regulatory Planning and Review,'' 58 FR 51735 (Oct. 4, 1993), agencies must, to the extent permitted by law, assess both the costs and the benefits of the intended regulation and, recognizing that some costs and benefits are difficult to quantify, propose or adopt a regulation only upon a reasoned determination that the benefits of the intended regulation justify its costs. The purpose of the SCC estimates presented here is to allow agencies to incorporate the monetized social benefits of reducing CO_2 emissions into cost-benefit analyses of regulatory actions. The estimates are presented with an acknowledgement of the many uncertainties involved and with a clear understanding that they should be updated over time to reflect increasing knowledge of the science and economics of climate impacts.

As part of the interagency process that developed the SCC estimates, technical experts from numerous agencies met on a regular basis to consider public comments, explore the technical literature in relevant fields, and discuss key model inputs and assumptions. The main objective of this process was to develop a range of SCC values using a defensible set of input assumptions grounded in the existing scientific and economic literatures. In this way, key uncertainties and model differences transparently and consistently inform the range of SCC estimates used in the rulemaking process.

a. Monetizing Carbon Dioxide Emissions

When attempting to assess the incremental economic impacts of carbon dioxide emissions, the analyst faces a number of challenges. A recent report from the National Research Council[110] points out that any assessment will suffer from uncertainty, speculation, and lack of information about: (1) Future emissions of greenhouse gases; (2) the effects of past and future emissions on the climate system; (3) the impact of changes in climate on the physical and biological environment; and (4) the translation of these environmental impacts into economic damages. As a result, any effort to quantify and monetize the harms associated with climate change will raise questions of science, economics, and ethics and should be viewed as provisional.

[110] National Research Council, *Hidden Costs of Energy: Unpriced Consequences of Energy Production and Use,* National Academies Press: Washington, DC (2009).

Despite the limits of both quantification and monetization, SCC estimates can be useful in estimating the social benefits of reducing carbon dioxide emissions. The agency can estimate the benefits from reduced (or costs from increased) emissions in any future year by multiplying the change in emissions in that year by the SCC value appropriate for that year. The net present value of the benefits can then be calculated by multiplying the future benefits by an appropriate discount factor and summing across all affected years.

It is important to emphasize that the interagency process is committed to updating these estimates as the science and economic understanding of climate change and its impacts on society improves over time. In the meantime, the interagency group will continue to explore the issues raised by this analysis and consider public comments as part of the ongoing interagency process.

b. Development of Social Cost of Carbon Values

In 2009, an interagency process was initiated to offer a preliminary assessment of how best to quantify the benefits from reducing carbon dioxide emissions. To ensure consistency in how benefits are evaluated across agencies, the Administration sought to develop a transparent and defensible method, specifically designed for the rulemaking process, to quantify avoided climate change damages from reduced CO_2 emissions. The interagency group did not undertake any original analysis. Instead, it combined SCC estimates from the existing literature to use as interim values until a more comprehensive analysis could be conducted. The outcome of the preliminary assessment by the interagency group was a set of five interim values: Global SCC estimates for 2007 (in 2006$) of $55, $33, $19, $10, and $5 per metric ton of CO_2. These interim values represented the first sustained interagency effort within the U.S. government to develop an SCC for use in regulatory analysis. The results of this preliminary effort were presented in several proposed and final rules.

c. Current Approach and Key Assumptions

After the release of the interim values, the interagency group reconvened on a regular basis to generate improved SCC estimates. Specifically, the group considered public comments and further explored the technical literature in relevant fields. The interagency group relied on three integrated assessment models commonly used to estimate the SCC: the FUND, DICE, and PAGE models. These models are frequently cited in the peer-reviewed literature and were used in the last assessment of the Intergovernmental Panel on Climate Change (IPCC). Each model was given equal weight in the SCC values that were developed.

Each model takes a slightly different approach to model how changes in emissions result in changes in economic damages. A key objective of the interagency process was to enable a consistent exploration of the three models, while respecting the different approaches to quantifying damages taken by the key modelers in the field. An extensive review of the literature was conducted to select three sets of input parameters for these models: Climate sensitivity, socio-economic and emissions trajectories, and discount rates. A probability distribution for climate sensitivity was specified as an input into all three models. In addition, the interagency group used a range of scenarios for the socio-economic parameters and a range of values for the discount rate. All other model features were left unchanged, relying on the model developers' best estimates and judgments.

In 2010, the interagency group selected four sets of SCC values for use in regulatory analyses. Three sets of values are based on the average SCC from three integrated assessment models, at discount rates of 2.5 percent, 3 percent, and 5 percent. The fourth set, which represents the 95th-percentile SCC estimate across all three models at a 3-percent discount rate, is included to represent higher-than-expected impacts from climate change further out in the tails of the SCC distribution. The values grow in real terms over time. Additionally, the interagency group determined that a range of values from 7 percent to 23 percent should be used to adjust the global SCC to calculate domestic effects,[111] although preference is given to consideration of the global benefits of reducing CO_2 emissions. Table IV.38 presents the values in the 2010 interagency group report,[112] which is reproduced in appendix 14A of the NOPR TSD.

TABLE IV.38—ANNUAL SCC VALUES FROM 2010 INTERAGENCY REPORT, 2010–2050

[In 2007 dollars per metric ton CO_2]

Year	Discount rate			
	5%	3%	2.5%	3%
	Average	Average	Average	95th Percentile
2010	4.7	21.4	35.1	64.9
2015	5.7	23.8	38.4	72.8
2020	6.8	26.3	41.7	80.7
2025	8.2	29.6	45.9	90.4
2030	9.7	32.8	50.0	100.0
2035	11.2	36.0	54.2	109.7
2040	12.7	39.2	58.4	119.3
2045	14.2	42.1	61.7	127.8
2050	15.7	44.9	65.0	136.2

The SCC values used for this document were generated using the most recent versions of the three integrated assessment models that have been published in the peer-reviewed literature, as described in the 2013 update from the interagency working group (revised July 2015).[113] Table IV.39 shows the updated sets of SCC estimates from the latest interagency update in 5-year increments from 2010 to 2050. The full set of annual SCC values between 2010 and 2050 is reported in appendix 14B of the NOPR TSD. The central value that emerges is the average SCC across models at the 3-percent discount rate. However, for purposes of capturing the uncertainties involved in regulatory impact analysis, the interagency group emphasizes the importance of including all four sets of SCC values.

TABLE IV.39—ANNUAL SCC VALUES FROM 2013 INTERAGENCY UPDATE (REVISED JULY 2015), 2010–2050

[In 2007 dollars per metric ton CO_2]

Year	Discount rate			
	5%	3%	2.5%	3%
	Average	Average	Average	95th Percentile
2010	10	31	50	86

[111] It is recognized that this calculation for domestic values is approximate, provisional, and highly speculative. There is no *a priori* reason why domestic benefits should be a constant fraction of net global damages over time.

[112] Interagency Working Group on Social Cost of Carbon, United States Government, *Social Cost of Carbon for Regulatory Impact Analysis Under Executive Order 12866* (February 2010) (Available at: *http://www.whitehouse.gov/sites/default/files/omb/inforeg/for-agencies/Social-Cost-of-Carbon-for-RIA.pdf).*

[113] *Technical Update of the Social Cost of Carbon for Regulatory Impact Analysis Under Executive Order 12866,* Interagency Working Group on Social Cost of Carbon, United States Government (May 2013; revised July 2015) (Available at: *http://www.whitehouse.gov/sites/default/files/omb/inforeg/scc-tsd-final-july-2015.pdf*).

TABLE IV.39—ANNUAL SCC VALUES FROM 2013 INTERAGENCY UPDATE (REVISED JULY 2015), 2010–2050—Continued

[In 2007 dollars per metric ton CO_2]

Year	Discount rate			
	5%	3%	2.5%	3%
	Average	Average	Average	95th Percentile
2015	11	36	56	105
2020	12	42	62	123
2025	14	46	68	138
2030	16	50	73	152
2035	18	55	78	168
2040	21	60	84	183
2045	23	64	89	197
2050	26	69	95	212

It is important to recognize that a number of key uncertainties remain, and that current SCC estimates should be treated as provisional and revisable since they will evolve with improved scientific and economic understanding. The interagency group also recognizes that the existing models are imperfect and incomplete. The National Research Council report mentioned above points out that there is tension between the goal of producing quantified estimates of the economic damages from an incremental ton of carbon and the limits of existing efforts to model these effects. There are a number of analytical challenges that are being addressed by the research community, including research programs housed in many of the Federal agencies participating in the interagency process to estimate the SCC. The interagency group intends to periodically review and reconsider those estimates to reflect increasing knowledge of the science and economics of climate impacts, as well as improvements in modeling. Although uncertainties remain, the revised estimates used for this NOPR are based on the best available scientific information on the impacts of climate change. The current estimates of the SCC have been developed over many years, and with input from the public. In November 2013, OMB announced a new opportunity for public comments on the interagency technical support document underlying the revised SCC estimates. 78 FR 70586 (Nov. 26, 2013). In July 2015, OMB published a detailed summary and formal response to the many comments that were received.[114] It also stated its intention to seek independent expert advice on opportunities to improve the estimates, including many of the approaches suggested by commenters. DOE stands ready to work with OMB and the other members of the interagency working group on further review and revision of the SCC estimates as appropriate.

In summary, in considering the potential global benefits resulting from reduced CO_2 emissions, DOE used the values from the 2013 interagency report (revised July 2015), adjusted to 2014$ using the gross domestic product (GDP) price deflator from the Bureau of Economic Analysis. For each of the four cases specified, the values used for emissions in 2015 were $12.2, $40.0, $62.3, and $117 per metric ton avoided (values expressed in 2014$). DOE derived values after 2050 using the relevant growth rates for the 2040–2050 period in the interagency update.

DOE multiplied the CO_2 emissions reduction estimated for each year by the SCC 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 SCC values in each case.

2. Social Cost of Other Air Pollutants

As noted previously, DOE has estimated how the considered energy conservation standards would reduce site NO_X emissions nationwide and decrease power sector NO_X emissions in those 22 States not affected by the CAIR.

DOE estimated the monetized value of NO_X emissions reductions using benefit per ton estimates from the Regulatory Impact Analysis titled, ''Proposed Carbon Pollution Guidelines for Existing Power Plants and Emission Standards for Modified and Reconstructed Power Plants,'' published in June 2014 by EPA's Office of Air Quality Planning and Standards. The report includes high and low values for NO_X (as $PM_{2.5}$) for 2020, 2025, and 2030 discounted at 3 percent and 7 percent,[115] which are presented in chapter 14 of the NOPR TSD. DOE assigned values for 2021–2024 and 2026–2029 using, respectively, the values for 2020 and 2025. DOE assigned values after 2030 using the value for 2030.

DOE multiplied the emissions reduction (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 for evaluate the monetization of avoided NO_X emissions and will make any appropriate updates of the current analysis for the final rulemaking.

DOE is evaluating appropriate monetization of avoided SO_2 and Hg emissions in energy conservation standards rulemakings. DOE has not included monetization of those emissions in the current analysis.

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 NEMS, associated with *AEO 2015*. NEMS produces the *AEO* Reference case, as well as a number of side cases that

[114] Available at: *https://www.whitehouse.gov/blog/2015/07/02/estimating-benefits-carbon-dioxide-emissions-reductions.*

[115] For the monetized NO_X benefits associated with $PM_{2.5}$, the related benefits (derived from benefit-per-ton values) are based on an estimate of premature mortality derived from the ACS study (Krewski et al. 2009), which is the lower of the two EPA central tendencies. Using the lower value is more conservative when making the policy decision concerning whether a particular standard level is economically justified so using the higher value would also be justified. If the benefit-per-ton estimates were based on the Six Cities study (Lepuele *et al.* 2012), the values would be nearly two-and-a-half times larger. (See chapter 14 of the NOPR TSD for further description of the studies mentioned above.)

estimate the economy-wide impacts of changes to energy supply and demand. DOE uses published side cases that incorporate efficiency-related policies to estimate the marginal impacts of reduced energy demand on the utility sector. These marginal factors are estimated based on the changes to electricity sector generation, installed capacity, fuel consumption and emissions in the *AEO* 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 new or amended energy conservation standards.

N. Employment Impact Analysis

Employment impacts from new or amended energy conservation standards include direct and indirect impacts. Direct employment impacts are any changes in the number of employees of manufacturers of the equipment subject to standards; the MIA addresses those impacts. Indirect employment impacts are changes in national employment that occur due to the shift in expenditures and capital investment caused by the purchase and operation of more-efficient appliances. Indirect employment impacts from standards consist of the jobs created or eliminated in the national economy, other than in the manufacturing sector being regulated, due to: (1) Reduced spending by end users on energy; (2) reduced spending on new energy supply by the utility industry; (3) increased commercial consumer spending on the purchase of new equipment; 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.[116] 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 commercial consumer utility bills. Because reduced commercial 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, based on the BLS data alone, DOE tentatively concludes net national employment may increase because of shifts in economic activity resulting from amended energy conservation standards for CWH equipment.

For the amended standard levels considered in this NOPR, DOE estimated indirect national employment impacts using an input/output model of the U.S. economy called Impact of Sector Energy Technologies version 3.1.1 (ImSET).[117] 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 the 187 sectors. ImSET's national economic I–O structure is based on a 2002 U.S. benchmark table, specially aggregated to the 187 sectors most relevant to industrial, commercial, and residential building energy use. DOE notes that ImSET is not a general equilibrium forecasting model, and understands the uncertainties involved in projecting employment impacts, especially changes in the later years of the analysis. Because ImSET does not incorporate price changes, the employment effects predicted by ImSET may over-estimate actual job impacts over the long run. For the NOPR, DOE used ImSET only to estimate short-term (through 2023) employment impacts.

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 potential amended energy conservation standards for the CWH equipment that is the subject of this rulemaking. It addresses the TSLs examined by DOE, the projected impacts of each of these levels if adopted as energy conservation standards for CWH equipment, and the proposed standard levels that DOE sets forth in this NOPR. Additional details regarding DOE's analyses are contained in the TSD chapters supporting this document.

A. Trial Standard Levels

DOE developed trial standard levels (TSLs) that combine efficiency levels for each analyzed equipment class of CWH equipment. DOE developed TSLs so that each TSL is composed of energy efficiency levels from each equipment class that exhibit similar characteristics, such as efficiency, or meet certain economic criteria. For example, one of the TSLs consists of the max-tech efficiency levels from each equipment class being considered for this rulemaking. DOE attempted to limit the number of TSLs considered for the NOPR by only considering efficiency levels that exhibit significantly different economic and/or engineering characteristics from the efficiency levels already selected as a TSL. DOE developed TSLs that include efficiency levels for both thermal efficiency and standby loss because standby loss is dependent upon thermal efficiency. This dependence of standby loss on thermal efficiency is discussed in detail in section IV.C.3.b and chapter 5 of the NOPR TSD. DOE developed the efficiency levels for thermal efficiency and standby loss for each equipment class in each TSL that DOE has identified for CWH equipment, as described below and as presented in Table V.1.

TSL 4 consists of the max-tech efficiency levels. The efficiency levels in TSL 4 also provide the highest NPV using a 7-percent discount rate.

TSL 3 consists of intermediate condensing efficiency levels for each gas-fired equipment class with the exception of the residential-duty gas-fired storage water heater equipment class, which has a minimum condensing level. All equipment classes have positive life-cycle cost savings at TSL 3. For this TSL, DOE selected thermal efficiency levels closest to the current

[116] See U.S. Department of Commerce, Bureau of Economic Analysis, *Regional Multipliers: A User Handbook for the Regional Input-Output Modeling System (RIMS II)* (1992).

[117] M. J. Scott, O. V. Livingston, P. J. Balducci, J. M. Roop, and R. W. Schultz, *ImSET 3.1: Impact of Sector Energy Technologies* (2009) Pacific Northwest National Laboratory: Report No. PNNL–18412 (Available at: *www.pnl.gov/main/publications/external/technical_reports/PNNL-18412.pdf).*

ENERGY STAR level [118] for commercial gas-fired storage water heaters and gas-fired instantaneous water heaters and hot water supply boilers. For this TSL, all selected standby loss levels maximize energy savings and have a positive NPV using a 7-percent discount rate.

TSL 2 consists of minimum condensing thermal efficiency levels for each gas-fired equipment class. For this TSL, all selected standby loss levels maximize both energy savings and NPV using a 7-percent discount rate.

TSL 1 consists of maximum non-condensing thermal efficiency levels for each gas-fired equipment class. For this TSL, all selected standby loss levels maximize energy savings and have a positive NPV using a 7-percent discount rate.

Table V.1 presents the efficiency levels for thermal efficiency and standby loss for each equipment class in each TSL that DOE has identified for CWH equipment. Table V.2 presents the thermal efficiency value and standby loss reduction factor for each equipment class in each TSL that DOE considered, with the exception of residential-duty gas-fired storage water heaters. The standby loss reduction factor is a multiplier representing the reduction in allowed standby loss relative to the current standby loss standard. For residential-duty gas-fired storage water heaters, DOE must set standards in terms of the uniform efficiency descriptor (UEF) metric established in the July 2014 final rule. 79 FR 40542, 40578–79 (July 11, 2014). Table V.3 presents the UEF equations for residential-duty gas-fired storage water heaters corresponding to each TSL that DOE considered, developed using the conversion factors proposed in the April 2015 NOPR. 80 FR 20116, 20143 (April 14, 2015).

TABLE V.1—TRIAL STANDARD LEVELS FOR CWH EQUIPMENT BY EFFICIENCY LEVEL

Equipment class	Trial standard level * **							
	1		2		3		4	
	E_t	SL	E_t	SL	E_t	SL	E_t	SL
Commercial gas-fired storage water heaters and storage-type instantaneous water heaters	1	2	2	2	4	2	5	2
Residential-duty gas-fired storage water heaters	1	3	2	1	2	1	4	1
Gas-fired instantaneous water heaters and hot water supply boilers:								
Tankless water heaters	2		3		4		5	
Hot water supply boilers	2		3		4		5	
Electric storage water heaters		1		1		1		1

* E_t stands for thermal efficiency, and SL stands for standby loss.
** As discussed in sections III.C.7 and III.C.8, DOE did not analyze amended energy conservations standards for standby loss of instantaneous water heaters and hot water supply boilers or for thermal efficiency of electric storage water heaters.

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 class	Trial standard level * **							
	1		2		3		4	
	E_t (%)	SL factor †	E_t (%)	SL factor †	E_t (%)	SL factor †	E_t (%)	SL factor †
Commercial gas-fired storage water heaters and storage-type instantaneous water heaters	82	0.72	90	0.67	95	0.63	99	0.61
Gas-fired instantaneous water heaters and hot water supply boilers:								
Tankless water heaters	84		92		94		96	
Hot water supply boilers	84		92		94		96	
Electric storage water heaters		0.84		0.84		0.84		0.84

* E_t stands for thermal efficiency, and SL stands for standby loss.
** As discussed in sections III.C.7 and III.C.8, DOE did not analyze amended energy conservations standards for standby loss of instantaneous water heaters and hot water supply boilers or for thermal efficiency of electric storage water heaters.
† 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.8.

TABLE V.3—TRIAL STANDARD LEVELS BY UEF FOR RESIDENTIAL-DUTY GAS-FIRED STORAGE WATER HEATERS

Draw pattern *	TSL 0	TSL 1	TSL 2	TSL 3	TSL 4
High	$0.6215 - (0.0007 \times Vr)$	$0.6646 - (0.0006 \times Vr)$	$0.7311 - (0.0006 \times Vr)$	$0.7311 - (0.0006 \times Vr)$	$0.7718 - (0.0006 \times Vr)$

[118] Chapter 3 of the NOPR TSD includes more detail on the ENERGY STAR program for commercial water heaters.

TABLE V.3—TRIAL STANDARD LEVELS BY UEF FOR RESIDENTIAL-DUTY GAS-FIRED STORAGE WATER HEATERS—Continued

Draw pattern *	TSL 0	TSL 1	TSL 2	TSL 3	TSL 4
Medium	0.5781 − (0.0009 × Vr)	0.6304 − (0.0007 × Vr)	0.6996 − (0.0007 × Vr)	0.6996 − (0.0007 × Vr)	0.7357 − (0.0008 × Vr)
Low	0.5316 − (0.0009 × Vr)	0.5915 − (0.0009 × Vr)	0.6626 − (0.0009 × Vr)	0.6626 − (0.0009 × Vr)	0.6939 − (0.0010 × Vr)
Very Small	0.3371 − (0.0007 × Vr)	0.3986 − (0.0009 × Vr)	0.4618 − (0.0010 × Vr)	0.4618 − (0.0010 × Vr)	0.4730 − (0.0011 × 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.

Note: TSL 0 represents the baseline, and Vr is rated volume in gallons.

B. Economic Justification and Energy Savings

1. Economic Impacts on Individual Commercial Consumers

DOE analyzed the economic impacts on CWH commercial consumers by looking at the effects potential amended standards would have on the LCC and PBP. DOE also examined the impacts of potential standards on commercial consumer subgroups. These analyses are discussed in the following subsections.

a. Life-Cycle Cost and Payback Period

To evaluate the net economic impact of potential amended energy conservation standards on commercial consumers of CWH equipment, DOE conducted LCC and PBP analyses for each TSL. In general, higher-efficiency equipment would affect commercial consumers in two ways: (1) Annual operating expenses would decrease, and (2) purchase price would increase. The results of the LCC analysis for each TSL were obtained by comparing the installed and operating costs of the equipment in the no-new-standards-case scenario (see section IV.F for a discussion of no-new-standards-case efficiency distribution) against the standards-case scenarios at each TSL. Inputs used for calculating the LCC and PBP include total installed costs (*i.e.,* equipment price plus installation costs), operating expenses (*i.e.,* annual energy use, energy prices, energy price trends, repair costs, and maintenance costs), equipment lifetime, and discount rates.

The LCC analysis is carried out using Monte Carlo simulations. Consequently, the results of the LCC analysis are distributions covering a range of values, as opposed to a single deterministic value. DOE presents the mean values calculated from the distributions of results. The LCC analysis also provides information on the percentage of commercial consumers for whom an increase in the minimum efficiency standard would have a positive impact (net benefit), a negative impact (net cost), or no impact.

DOE also performed a PBP analysis as part of the LCC analysis. The PBP is the number of years it would take for the commercial consumer to recover the increased costs of higher-efficiency equipment as a result of energy savings based on the operating cost savings. The PBP is an economic benefit-cost measure that uses benefits and costs without discounting. Chapter 8 of the NOPR TSD provides detailed information on the LCC and PBP analyses.

As described in section IV.H of this document, DOE used a ''roll-up'' scenario in this rulemaking. Under the roll-up scenario, DOE assumes that the market shares of the efficiency levels in the no-new-standards case that do not meet the new or amended standard level under consideration would ''roll up'' into (meaning ''be added to'') the market share of the efficiency level at the standard level under consideration, and the market shares of efficiency levels that are above the standard level under consideration would remain unaffected. Commercial consumers in the no-new-standards-case scenario who buy the equipment at or above the TSL under consideration, would be unaffected if the standard were to be set at that TSL. Commercial consumers in the no-new-standards-case scenario who buy equipment below the TSL under consideration would be affected if the standard were to be set at that TSL. Among these affected commercial consumers, some may benefit from lower LCCs of the equipment, and some may incur net cost due to higher LCCs, depending on the inputs to the LCC analysis such as electricity prices, discount rates, installation costs, and markups.

DOE's LCC and PBP analyses provided key outputs for each efficiency level above the baseline for each equipment class, as reported in Table V.4 to Table V.15. Two tables are presented for each equipment class, with separate pairs of tables shown for tankless gas-fired water heaters and for gas-fired hot water supply boilers, two product groups within the class of gas-fired instantaneous water heaters and hot water supply boilers. LCC results for this class as a whole are also shown based on shipment weighting of both equipment groups. The first table in each pair presents the results of the LCC analysis by efficiency level and TSL and shows installed costs, first year's operating cost, lifetime operating cost, and mean LCC, as well as simple PBP. The second table presents the percentage of commercial consumers who experience a net cost, as well as the mean LCC savings for all commercial consumers.

Analysis of all equipment classes showed positive mean LCC savings values at TSL 4, the max-tech efficiency level. The percentage of consumers experiencing net cost at TSL 4 varied from 14 percent for electric storage water heaters to 36 percent for residential duty gas-fired storage water heaters.

For commercial gas-fired storage and residential-duty gas-fired storage water heaters, the trend is generally an increase in LCC savings from TSL 2 to 4, going from lowest to highest condensing efficiency level examined. Average LCC savings are positive at TSL 1 through TSL 4 for all equipment classes.

For commercial gas-fired storage water heaters, and gas-fired instantaneous water heaters and hot water supply boilers, TSL 2 showed positive mean LCC savings, with between 22 and 38 percent of commercial consumers showing negative LCC savings. For residential-duty gas-fired storage water heaters, 42 percent of consumers experienced net cost at TSL 2. TSL 1 showed positive LCC savings for all equipment classes.

The simple PBP values for TSLs 2 through 4 are generally less than 7 years, except for residential-duty gas-fired storage water heater class, which has a simple payback ranging from 10.2 to 11.9 years, depending on TSL. Analyzed payback periods for the equipment group of gas-fired tankless water heaters were immediate at TSL 2 through TSL 4, resulting from reduced venting costs that offset equipment cost increases, particularly in new construction. The PBP was less than the average lifetime in all cases.

TABLE V.4—AVERAGE LCC AND PBP RESULTS BY EFFICIENCY LEVEL FOR COMMERCIAL GAS-FIRED STORAGE WATER HEATERS

TSL *	Thermal efficiency (E_t) (%)	Standby loss (SL) factor	Average costs (2014$)				Simple payback period (years)
			Installed cost	First year's operating cost	Lifetime operating cost	LCC	
0	80	1.00	4,316	2,225	20,011	24,327	....
1	82	0.72	4,581	2,156	19,378	23,959	3.8
2	90	0.67	5,467	2,023	18,149	23,615	5.7
3	95	0.63	5,537	1,944	17,415	22,952	4.3
4	99	0.61	5,624	1,883	16,863	22,488	3.8

* The results for each TSL are calculated assuming that all commercial 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 EFFICIENCY DISTRIBUTION FOR COMMERCIAL GAS-FIRED STORAGE WATER HEATERS

TSL	Thermal efficiency (E_t) level	Standby loss (SL) factor	Life-cycle cost savings	
			Percentage of commercial consumers that experience a net cost	Average life-cycle cost savings * (2014$)
0	80	1.00	0	....
1	82	0.72	8	219
2	90	0.67	30	317
3	95	0.63	24	794
4	99	0.61	21	1,252

* The calculation includes commercial consumers with zero LCC savings (no impact).
Note: TSL 0 represents the baseline.

TABLE V.6—AVERAGE LCC AND PBP RESULTS BY EFFICIENCY LEVEL FOR RESIDENTIAL-DUTY GAS-FIRED STORAGE WATER HEATERS

TSL *	UEF	Average costs (2014$)				Simple payback period (years)
		Installed cost	First year's operating cost	Lifetime operating cost	LCC	
0	0.57	2,090	1,252	13,066	15,156	....
1	0.62	2,528	1,210	12,609	15,136	10.5
2, 3	0.69	3,361	1,145	11,886	15,248	11.9
4	0.73	3,669	1,096	11,361	15,030	10.2

* The results for each TSL are calculated assuming all commercial consumers use equipment with that efficiency level. The PBP is measured relative to the baseline equipment. UEF values are for the representative model.
Note: TSL 0 represents the baseline.

TABLE V.7—AVERAGE LCC SAVINGS RELATIVE TO THE NO-NEW-STANDARDS-CASE EFFICIENCY DISTRIBUTION FOR RESIDENTIAL-DUTY GAS-FIRED STORAGE WATER HEATERS

TSL	UEF	Life-cycle cost savings *	
		Percentage of commercial consumers that experience a net cost	Average life-cycle cost savings ** (2014$)
0	0.57	0	....
1	0.62	32	537
2, 3	0.69	42	14

TABLE V.7—AVERAGE LCC SAVINGS RELATIVE TO THE NO-NEW-STANDARDS-CASE EFFICIENCY DISTRIBUTION FOR RESIDENTIAL-DUTY GAS-FIRED STORAGE WATER HEATERS—Continued

TSL	UEF	Life-cycle cost savings *	
		Percentage of commercial consumers that experience a net cost	Average life-cycle cost savings ** (2014$)
4	0.73	36	241

* A value in parentheses is a negative number.
** The calculation includes commercial consumers with zero LCC savings (no impact).
Note: UEF values are for the representative model.
TSL 0 represents the baseline.

TABLE V.8—AVERAGE LCC AND PBP RESULTS BY EFFICIENCY LEVEL FOR GAS-FIRED TANKLESS WATER HEATERS

TSL*	Thermal efficiency (E_t) (%)	Average costs (2014$)				Simple payback period years
		Installed cost	First year's operating cost	Lifetime operating cost	LCC	
0	80	4,273	690	9,607	13,880	
1	84	4,337	668	9,283	13,620	2.9
2	92	3,819	622	8,628	12,447	Immediate.
3	94	3,849	611	8,474	12,322	Immediate.
4	96	3,884	600	8,325	12,209	Immediate.

* The results for each TSL are calculated assuming that all commercial consumers use equipment with that efficiency level. The PBP is measured relative to the baseline equipment.
Note: Immediate payback can result from a decrease in installation cost that is greater than the incremental increase in equipment cost.
TSL 0 represents the baseline.

TABLE V.9—AVERAGE LCC SAVINGS RELATIVE TO THE NO-NEW-STANDARDS-CASE EFFICIENCY DISTRIBUTION FOR GAS-FIRED TANKLESS WATER HEATERS

TSL	Thermal efficiency (E_t) (%)	Life-cycle cost savings	
		Percentage of commercial consumers that experience a net cost	Average life-cycle cost savings * (2014$)
0	80	0	
1	84	11	86
2	92	38	1,009
3	94	35	1,119
4	96	33	1,224

* The calculation includes commercial 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 HOT WATER SUPPLY BOILERS

TSL*	Thermal efficiency (E_t) (%)	Average costs (2014$)				Simple payback period (years)
		Installed cost	First year's operating cost	Lifetime operating cost	LCC	
0	80	7,372	3,990	74,284	81,656	
1	84	7,961	3,828	71,216	79,178	3.6
2	92	10,113	3,579	65,754	75,867	6.7
3	94	10,433	3,514	64,516	74,949	6.4
4	96	10,754	3,452	63,325	74,079	6.3

* The results for each TSL are calculated assuming that all commercial 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 HOT WATER SUPPLY BOILERS

TSL	Thermal efficiency (E_t) (%)	Life-cycle cost savings	
		Percentage of commercial consumers that experience a net cost	Average life-cycle cost savings * (2014$)
0	80	0	
1	84	15	1,245
2	92	22	3,794
3	94	22	4,528
4	96	24	5,285

* The calculation includes commercial 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) (%)	Average costs (2014$)				Simple payback period (years)
		Installed cost	First year's operating cost	Lifetime operating cost	LCC	
0	80	6,427	2,984	54,556	60,983	
1	84	6,856	2,864	52,325	59,181	3.6
2	92	8,193	2,677	48,330	56,523	5.8
3	94	8,425	2,629	47,422	55,846	5.6
4	96	8,658	2,582	46,549	55,207	5.6

* 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.
** The results for each TSL are calculated assuming that all commercial consumers use equipment with that efficiency level. The PBP is measured relative to the baseline equipment.
Note: TSL 0 represents the baseline.

TABLE V.13—AVERAGE LCC SAVINGS RELATIVE TO THE NO-NEW-STANDARDS-CASE EFFICIENCY DISTRIBUTION FOR GAS-FIRED INSTANTANEOUS WATER HEATERS AND HOT WATER SUPPLY BOILERS *

TSL	Thermal efficiency (E_t) (%)	Life-cycle cost savings	
		Percentage of commercial consumers that experience a net cost	Average life-cycle cost savings ** (2014$)
0	80	0	
1	84	14	891
2	92	27	2,944
3	94	26	3,488
4	96	27	4,046

* 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.
** The calculation includes commercial consumers with zero LCC savings (no impact).
Note: TSL 0 represents the baseline.

TABLE V.14—AVERAGE LCC AND PBP RESULTS BY EFFICIENCY LEVEL FOR ELECTRIC STORAGE WATER HEATERS

TSL *	Standby loss (SL) factor	Average costs (2014$)				Simple payback period (years)
		Installed cost	First year's operating cost	Lifetime operating cost	LCC	
0	1.00	3,649	1,743	17,094	20,743	
1, 2, 3, 4	0.84	3,743	1,728	16,952	20,694	6.5

* The results for each TSL are calculated assuming that all commercial consumers use equipment with that efficiency level. The PBP is measured relative to the baseline equipment.
Note: TSL 0 represents the baseline.

TABLE V.15—AVERAGE LCC SAVINGS RELATIVE TO THE NO-NEW-STANDARDS-CASE EFFICIENCY DISTRIBUTION FOR ELECTRIC STORAGE WATER HEATERS

TSL	Standby loss (SL) level	Life-cycle cost savings	
		Percentage of commercial consumers that experience a net cost	Average life-cycle cost savings * (2014$)
0	1.00	0	
1, 2, 3, 4	0.84	14	47

* The calculation includes commercial consumers with zero LCC savings (no impact).
Note: TSL 0 represents the baseline.

b. Life-Cycle Cost Subgroup Analysis

As described in section IV.I, DOE estimated the impact of amended energy conservation standards for commercial water heating equipment. Using the LCC spreadsheet model, DOE estimated the impacts of the TSLs on the following commercial consumer subgroups: Low-income residential population (0–20 percent percentile gross annual household income) and small businesses. DOE estimated the average LCC savings and PBP for the low-income subgroup compared with average CWH commercial consumers, as shown in Table V.16 through Table V.21. DOE also estimated LCC savings and PBP for small businesses, presenting the results in Table V.16 through Table V.21.

The results of the life-cycle cost subgroup analysis indicate that for CWH equipment, the low-income residential subgroup in general had a slightly higher LCC savings when compared to the general commercial consumer population, due in part to greater hot water use than the average commercial consumer for all equipment classes with the exception of residential-duty. However, for both residential-duty gas-fired commercial storage water heaters and for tankless water heating equipment, the low-income residential subgroup analyzed had somewhat lower hot water usage than the average commercial consumer of this equipment, which contributed to lower LCC savings for some TSLs. In particular, the low-income residential subgroup for the Residential-Duty Low-Income Gas-Fired Storage Water Heaters equipment class at TSL 2/3 would experience negative LCC savings and an associated payback period longer than the estimated 12 year lifetime of the product. DOE requests comment on any potential impacts of the estimated increased costs of the proposed standards on the low-income residential subgroup and whether this would impact the rate of replacement of the existing products due to low-income consumers choosing to repair as opposed to replace their water heater. In addition, DOE requests comment on the assumptions used in the LCC and PBP analysis such as the estimated installation costs of $3,361, which includes all applicable costs and markups for this equipment class. DOE also requests comment on the potential for product switching from either smaller Residential (>55 gallon, ≤75,000 Btu/h) or larger commercial (>105,000 Btu/h) gas storage hot water heaters to the Residential-Duty Gas-Fired Storage Water Heaters (>75,000 Btu/h and ≤105,000 Btu/h) equipment class if the agency were to adopt a less costly alternative for the Residential-Duty Gas-Fired Storage Water Heaters equipment class.

For the small business subgroups, the LCC savings were consistently lower than those of the average commercial consumer. Chapter 11 of the NOPR TSD provides more detailed discussion on the LCC subgroup analysis and results.

TABLE V.16—COMPARISON OF IMPACTS FOR CONSUMER SUBGROUPS WITH ALL CONSUMERS, COMMERCIAL GAS-FIRED STORAGE WATER HEATERS

TSL	Thermal efficiency (E_t) (%)	Standby loss (SL) factor	LCC savings (2014$) *			Simple payback period (years)		
			Residential low-income	Commercial small business	All	Residential low-income	Commercial small business	All
1	82	0.72	345	179	219	3.2	3.8	3.8
2	90	0.67	731	243	317	4.7	5.5	5.7
3	95	0.63	1,399	679	794	3.5	4.2	4.3
4	99	0.61	2,046	1,093	1,252	3.1	3.7	3.8

* Parentheses indicate negative values.

TABLE V.17—COMPARISON OF IMPACTS FOR CONSUMER SUBGROUPS WITH ALL CONSUMERS, RESIDENTIAL-DUTY GAS-FIRED STORAGE WATER HEATERS

TSL	UEF	LCC savings (2014$) *			Simple payback period (years)		
		Residential low-income	Commercial small business	All	Residential low-income	Commercial small business	All
1	0.62	587	467	537	9.8	10.5	10.5
2, 3	0.69	(17)	48	14	12.4	10.1	11.9
4	0.73	251	250	241	10.4	8.7	10.2

* Parentheses indicate negative values.

TABLE V.18—COMPARISON OF IMPACTS FOR CONSUMER SUBGROUPS WITH ALL CONSUMERS, GAS-FIRED TANKLESS WATER HEATERS

TSL	Thermal efficiency (E_t) (%)	LCC savings (2014$) *			Simple payback period (years)		
		Residential low-income	Commercial small business	All	Residential low-income	Commercial small business	All
1	84	94	62	86	2.9	3.1	2.9
2	92	748	1,036	1,009	Immediate	Immediate	Immediate.
3	94	869	1,121	1,119	Immediate	Immediate	Immediate.
4	96	985	1,199	1,224	Immediate	Immediate	Immediate.

* Parentheses indicate negative values.
Note: Immediate payback can result from a decrease in installation cost that is greater than the incremental increase in equipment cost.

TABLE V.19—COMPARISON OF IMPACTS FOR CONSUMER SUBGROUPS WITH ALL CONSUMERS, GAS-FIRED HOT WATER SUPPLY BOILERS

TSL	Thermal efficiency (E_t) (%)	LCC savings (2014$) *			Simple payback period (years)		
		Residential low-income	Commercial small business	All	Residential low-income	Commercial small business	All
1	84	2,937	401	1,245	2.1	6.4	3.6
2	92	9,568	761	3,794	4.1	12.2	6.7
3	94	11,302	979	4,528	4.0	11.7	6.4
4	96	13,101	1,192	5,285	3.8	11.4	6.3

* Parentheses indicate negative values.

TABLE V.20—COMPARISON OF IMPACTS FOR CONSUMER SUBGROUPS WITH ALL CONSUMERS, GAS-FIRED INSTANTANEOUS WATER HEATERS AND HOT WATER SUPPLY BOILERS *

TSL	Thermal efficiency (E_t) (%)	LCC savings (2014$) *			Simple payback period (years)		
		Residential low-income	Commercial small business	All	Residential low-income	Commercial small business	All
1	84	2,070	298	891	2.1	6.1	3.6
2	92	6,878	845	2,944	3.9	9.7	5.8
3	94	8,120	1,022	3,488	3.8	9.5	5.6
4	96	9,406	1,195	4,046	3.7	9.3	5.6

* 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.19.
** Parentheses indicate negative values.

TABLE V.21—COMPARISON OF IMPACTS FOR CONSUMER SUBGROUPS WITH ALL CONSUMERS, ELECTRIC STORAGE WATER HEATERS

TSL	Standby loss (SL) factor	LCC savings (2014$) *			Simple payback period (years)		
		Residential low-income	Commercial small business	All	Residential low-income	Commercial small business	All
1,2,3,4	0.84	87	26	47	5.5	6.9	6.5

* Parentheses indicate negative values.

c. Rebuttable Presumption Payback

As discussed in section III.F.2, 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. Accordingly, DOE calculated a rebuttable presumption payback period for each TSL for commercial water heating equipment using average installed cost to the commercial consumer and first-year energy savings. However, DOE routinely conducts a full economic analysis that considers the full range of impacts, including those to the commercial consumer, manufacturer, Nation, and environment, as required by EPCA under 42 U.S.C. 6313(a)(6)(B)(ii) and (C)(i). The results of this more detailed analysis serve as the basis for DOE to definitively evaluate the economic justification for a potential standard level, thereby supporting or rebutting the results of any preliminary determination of economic justification. Table V.22 shows the rebuttable presumption payback periods for each CWH equipment class by TSL level. Rebuttable payback periods were greater than 3 years for all CWH equipment except the tankless water heaters subclass. Tankless water heaters had rebuttable presumption payback periods of less than 3 years at all TSL levels.

TABLE V.22—REBUTTABLE PRESUMPTION PAYBACK PERIODS FOR COMMERCIAL WATER HEATING EQUIPMENT CLASSES

Equipment class	Rebuttable presumption payback (years)			
	TSL 1	TSL 2	TSL 3	TSL 4
Gas-fired storage water heaters and storage-type instantaneous water heaters.	3.8	5.6	4.2	3.7.
Residential-duty gas-fired storage water heaters	10.5	11.3	11.3	9.6.
Gas-fired instantaneous water heaters and hot water supply boilers	3.4	5.1	5.0	5.0.
Tankless water heaters	2.3	Immediate	Immediate	Immediate.
Hot water supply boilers	3.5	5.9	5.8	5.7.
Electric storage water heaters	6.5	6.5	6.5	6.5.

Note: Immediate payback can result from a decrease in installation cost that is greater than the incremental increase in equipment cost.

2. Economic Impact on Manufacturers

As noted previously, 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

Table V.23 and Table V.24 depict the estimated financial impacts (represented by changes in INPV) of amended energy conservation standards on CWH equipment manufacturers, as well as the conversion costs that DOE expects manufacturers would incur for all equipment classes at each TSL. To evaluate the range of cash-flow impacts on the CWH industry, DOE modeled two markup scenarios using different assumptions that correspond to the range of anticipated market responses to amended energy conservation standards: (1) The preservation of gross margin percentage markup scenario; and (2) the preservation of per-unit operating profit markup scenario. Each of these scenarios is discussed immediately below.

To assess the less severe end of the range of potential impacts, DOE modeled a preservation of gross margin percentage markup scenario, in which a uniform ''gross margin percentage'' markup is applied across all potential efficiency levels. In this scenario, DOE assumed that a manufacturer's absolute dollar markup would increase as production costs increase in the standards case.

To assess the more severe end of the range of potential impacts, DOE modeled the preservation of per-unit operating profit markup scenario, which assumes that manufacturers would not be able to generate greater operating profit on a per-unit basis in the standards case as compared to the no-new-standards case. Rather, as manufacturers make the necessary investments required to convert their facilities to produce new standards-compliant equipment and incur higher costs of goods sold, their percentage markup decreases. Operating profit does not change in absolute dollars and decreases as a percentage of revenue.

As noted in the MIA methodology discussion (see section IV.J.2), in addition to markup scenarios, the MPCs, shipments, and conversion cost assumptions also affect INPV results.

The results in Table V.23 and Table V.24 show potential INPV impacts for CWH equipment manufacturers. Table V.23 reflects the less severe set of potential impacts, and Table V.24 represents the more severe set of potential impacts. 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 the base year 2015 through 2048, the end of the analysis period.

To provide perspective on the short-run 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.

TABLE V.23—MANUFACTURER IMPACT ANALYSIS RESULTS—PRESERVATION OF GROSS MARGIN PERCENTAGE MARKUP SCENARIO *

	Units	No-new-standards case	Trial standard level			
			1	2	3	4
INPV	*2014$ millions*	176.2	177.4	187.8	185.0	166.6
Change in INPV	*2014$ millions*		1.2	11.6	8.8	(9.7)
	%		0.7	6.6	5.0	(5.5)
Free Cash Flow (2018)	*2014$ millions*	12.8	10.9	5.6	2.5	(10.2)
Change in Free Cash Flow	*2014$ millions*		(2.0)	(7.3)	(10.3)	(23.1)
	%		(15.5)	(56.7)	(80.4)	(179.8)
Product Conversion Costs	*2014$ millions*		3.6	12.5	18.1	48.2
Capital Conversion Costs	*2014$ millions*		2.2	8.4	11.7	21.3
Total Conversion Costs	*2014$ millions*		5.8	20.9	29.8	69.6

* Parentheses indicate negative values.

TABLE V.24—MANUFACTURER IMPACT ANALYSIS RESULTS—PRESERVATION OF PER-UNIT OPERATING PROFIT MARKUP SCENARIO *

	Units	No-new-standards case	Trial standard level			
			1	2	3	4
INPV	*2014$ millions*	176.2	171.5	158.8	152.8	128.6
Change in INPV	*2014$ millions*		(4.7)	(17.4)	(23.4)	(47.6)
	%		(2.7)	(9.9)	(13.3)	(27.0)
Free Cash Flow (2018)	*2014$ millions*	12.8	10.9	5.6	2.5	(10.2)
Change in Free Cash Flow	*2014$ millions*		(2.0)	(7.3)	(10.3)	(23.1)
	%		(15.5)	(56.7)	(80.4)	(179.8)
Product Conversion Costs	*2014$ millions*		3.6	12.5	18.1	48.2
Capital Conversion Costs	*2014$ millions*		2.2	8.4	11.7	21.3
Total Conversion Costs	*2014$ millions*		5.8	20.9	29.8	69.6

* Parentheses indicate negative values.

At TSL 1, DOE estimates impacts on INPV for CWH equipment manufacturers to range from −2.7 percent to 0.7 percent, or a change of −$4.7 million to $1.2 million. At this level, DOE estimates that industry free cash flow would decrease by approximately 15.5 percent to $10.9 million, compared to the no-new-standards-case value of $12.8 million in the year before compliance (2018).

DOE estimates that in the year of compliance (2019), 27 percent of CWH shipments in the no-new-standards case would already meet or exceed the thermal efficiency and standby loss standards at TSL 1. At this level, DOE expects CWH equipment manufacturers to incur $3.6 million in product conversion costs to redesign and test their equipment. DOE does not expect the modest increases in thermal efficiency standards at this TSL to require major equipment redesigns or capital investments. However, DOE expects manufacturers to incur approximately $2.2 million in capital conversion costs in order to comply with the proposed standby loss levels at this TSL. DOE expects manufacturers will incur these costs to purchase new tooling for the machinery used to make the jackets for storage water heaters, which would need to expand to enclose a thicker tank insulation layer.

At TSL 1, under the preservation of gross margin percentage scenario, the shipment-weighted average price per unit increases by 4.5 percent relative to the no-new-standards-case price per unit in the year of compliance (2019). In this scenario, manufacturers are able to fully pass on this cost increase to commercial consumers. This slight price increase would mitigate the $5.8 million in total conversion costs estimated at TSL 1, resulting in slightly positive INPV impacts at TSL 1 under this scenario. Under the preservation of per-unit operating profit markup scenario, manufacturers earn the same operating profit as would be earned in the no-new-standards case, but do not earn additional profit from their investments. A weighted-average price increase of 4.1 percent in this scenario is outweighed by the expected $5.8 million in total conversion costs, resulting in slightly negative impacts at TSL 1.

At TSL 2, DOE estimates impacts on INPV for CWH manufacturers to range from −9.9 percent to 6.6 percent, or a change in INPV of −$17.4 million to $11.6 million. At this potential standard level, industry free cash flow would decrease by approximately 56.7 percent to $5.6 million, compared to the base-case value of $12.8 million in the year before compliance (2018).

DOE estimates that in the year of compliance (2019), 19 percent of CWH shipments in the no-new-standards case would already meet or exceed the thermal efficiency and standby loss standards at TSL 2. DOE estimates that conversion costs would increase significantly at this TSL because manufacturers would meet these thermal efficiency levels for gas-fired CWH equipment classes by using condensing technology, which significantly changes the equipment design. DOE estimates that most of these costs would be driven by commercial and residential-duty commercial gas-fired storage water heaters and gas-fired hot water supply boilers. DOE acknowledges that different manufacturers would likely make different investments in order to meet these thermal efficiency levels, because condensing heat exchanger designs vary from manufacturer to manufacturer. Manufacturers of gas-fired storage water heaters that use helical condensing heat exchanger designs may have to increase their tube-bending capacity to increase their production capacity of condensing heat exchangers, as would be required by a condensing standard. Other manufacturers may have to invest to increase their welding capacity. Additionally, manufacturers could incur capital costs for new press dies to form the holes for flue pipes in the top and bottom bells of storage water heaters. DOE estimated that manufacturers of the instantaneous CWH equipment classes would likely incur low capital conversion costs at this TSL. DOE assumes that tankless water heater manufacturers produce far more residential products than commercial products and that these products are manufactured in the same facilities with shared equipment. Therefore, DOE has tentatively concluded that increased production of condensing commercial tankless water heaters would not require high conversion costs because many more condensing residential tankless water heaters are already made. For hot water supply boilers, DOE assumes that manufacturers would likely choose to purchase condensing heat exchangers rather than design and manufacture them. While this shift to a purchased heat exchanger might affect the vertically-integrated structure of the manufacturer, DOE does not believe it would lead to high conversion costs. Overall, DOE estimates that manufacturers would incur $12.5 million in product conversion costs and $8.4 million in capital conversion costs to bring their CWH equipment portfolios into compliance with a standard set to TSL 2.

At TSL 2, under the preservation of gross margin percentage scenario, the shipment-weighted average price per unit increases by 20.9 percent relative to the no-new-standards-case price per unit in the year of compliance (2019). In this scenario, INPV impacts are positive because manufacturers' ability to pass higher production costs onto commercial consumers outweighs the $20.9 million in expected total conversion costs. However, under the preservation of per-unit operating profit markup scenario, a lower markup means the weighted average price per unit increases by only 18.9 percent compared to the no-new-standards case price per unit in the year of compliance (2019). In this case, conversion costs outweigh the gain in weighted average price per unit, resulting in moderately negative impacts at TSL 2.

At TSL 3, DOE estimates impacts on INPV for CWH manufacturers to range from −13.3 percent to 5.0 percent, or a change in INPV of −$23.4 million to $8.8 million. At this potential standard level, DOE estimates industry free cash flow would decrease by approximately 80.4 percent to $2.5 million compared to the no-new-standards-case value of $12.8 million in the year before compliance (2018).

The impacts on INPV at TSL 3 are slightly more negative than at TSL 2. DOE estimates that in the year of compliance (2019), 16 percent of CWH shipments in the no-new-standards case would 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, which would require increased engineering resources. Additionally, capital conversion costs would increase as manufacturers may have to upgrade their laboratories and test facilities to increase capacity for research, development, and testing for their gas-fired storage water heater offerings. Overall, DOE estimates that manufacturers would incur $18.1 million in product conversion costs and $11.7 million in capital conversion costs to bring their CWH equipment portfolios into compliance with a standard set to TSL 3.

At TSL 3, under the preservation of gross margin percentage markup scenario, the shipment-weighted average price per unit in the year of compliance (2019) increases by 23.1 percent relative to the no-new-standards case price per unit. In this scenario, INPV impacts are positive because manufacturers' ability to pass higher production costs onto commercial consumers outweighs the $29.8 million in total conversion costs. However, under the preservation of per-unit operating profit markup scenario, a lower markup means the weighted average price per unit increases by only 20.9 percent compared to the no-new-standards case price per unit in the year of compliance (2019). In this case, conversion costs outweigh the gain in weighted average price per unit, resulting in moderately negative impacts at TSL 3.

TSL 4 represents the max-tech thermal efficiency and standby loss levels for all equipment classes analyzed. At TSL 4, DOE estimates impacts on INPV for CWH equipment manufacturers to range from −27.0 percent to −5.5 percent, or a change in INPV of −$47.6 million to −$9.7 million. At this TSL, DOE estimates industry free cash flow in the year before compliance (2018) would decrease by approximately 179.8 percent to −$10.2 million compared to the no-new-standards case value of $12.8 million.

The impacts on INPV at TSL 4 are negative under both markup scenarios. DOE estimates that in 2019, only 4 percent of CWH equipment shipments would already meet or exceed the efficiency levels prescribed at TSL 4. DOE expects conversion costs to continue to increase at TSL 4, as almost all equipment on the market would have to be redesigned and many new products would have to be developed. DOE estimates that product conversion costs would increase to $48.2 million, as manufacturers would have to redesign a larger percentage of their offerings to meet max-tech for all classes. In particular, manufacturers of commercial gas-fired storage water heaters would need to extensively redesign almost all of their product offerings. This extensive redesign would likely include many rounds of research and development and testing across most equipment platforms. DOE estimates that manufacturers would also incur $21.3 million in capital conversion costs. In addition to upgrading production lines, DOE has tentatively concluded that manufacturers would likely be required to make extensive modifications and upgrades to their laboratories and possibly add laboratory space in order to develop and test products that meet max-tech efficiency levels, particularly for commercial gas-fired storage water heaters.

At TSL 4, under the preservation of gross margin percentage markup scenario, the shipment-weighted average price per unit in the year of compliance (2019) increases by 27.1 percent relative to the no-new-standards case price per unit. In this scenario, INPV impacts are negative because manufacturers' ability to pass higher production costs onto consumers is outweighed by the $69.6 million in total conversion costs. Under the preservation of per-unit operating profit markup scenario, a lower markup means the weighted-average price per unit increases by only 24.5 percent compared to the no-new-standards case price per unit in the year of compliance (2019). In this case, conversion costs outweigh the gain in weighted-average price per unit, resulting in significantly negative impacts at TSL 4.

b. Impacts on Direct Employment

To quantitatively assess the impacts of energy conservation standards on direct employment in the CWH industry, DOE used the GRIM to estimate the domestic labor expenditures and number of employees in the no-new-standards case and at each TSL in 2019. DOE used statistical data from the U.S. Census Bureau's 2013 Annual Survey of Manufacturers (ASM),[119] 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 each year are calculated by multiplying the MPCs by the labor percentage of MPCs.

The total labor expenditures in the GRIM are converted to domestic production employment levels by dividing production labor expenditures by the annual payment per production worker (production worker hours times the labor rate found in the U.S. Census Bureau's 2013 ASM). 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. DOE's estimates only account for production workers who manufacture the specific products covered by this rulemaking. The total direct employment impacts calculated in the GRIM are the sum of the changes in the number of production workers resulting from the amended energy conservation standards for CWH equipment, as compared to the no-new-standards case.

To estimate an upper bound to direct employment under amended standards, DOE assumes all domestic manufacturers would choose to continue producing CWH equipment in the United States and would not move production to foreign countries. To estimate a lower bound to direct employment under amended standards, DOE considers a case where some manufacturers choose to relocate some production overseas rather than make the necessary conversions at domestic production facilities. To establish the lower bound employment under amended standards, DOE estimated the maximum potential job loss due to manufacturers either leaving the industry or moving production to foreign locations as a result of amended standards. Due to shipping costs, most manufacturers agreed that more-stringent energy conservation standards for CWH equipment would probably not push their production overseas. Some manufacturers stated that producing higher-efficiency equipment is generally a more labor-intensive process and may cause them to hire additional production employees. They also noted, however, that higher efficiency standards could potentially shift the production of some of the value content of CWH equipment overseas, causing U.S. manufacturers to become less vertically integrated. In particular, manufacturers of hot water supply boilers could choose to source condensing heat exchangers, most of which are made overseas, rather than manufacture them at domestic production facilities.

DOE estimates that 90 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 377 domestic production workers in the CWH industry in 2019, the year of compliance. Table V.25 presents the range of potential impacts of amended energy conservation standards on U.S. production workers of CWH equipment.

TABLE V.25—POTENTIAL CHANGES IN THE TOTAL NUMBER OF CWH EQUIPMENT PRODUCTION WORKERS IN 2019

Worker estimates	No new standard	Trial standard level			
		1	2	3	4
Total Number of Domestic Production Workers (2019)	377	389 to 241	406 to 212	408 to 199	416 to 153
Potential Changes in Domestic Production Workers (2019)		12 to (136)	29 to (165)	31 to (178)	39 to (224)

* Numbers in parentheses indicate negative numbers.

At the upper end of the range, all examined TSLs show positive impacts on domestic employment levels. Producing more-efficient CWH equipment tends to require more labor, and DOE estimates that if CWH equipment manufacturers chose to keep their current production in the United States, domestic employment could increase at each TSL. In interviews, 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.

Regarding potential negative impacts on domestic direct employment, DOE does not expect significant changes at TSL 1. Most manufacturers agreed that these efficiency levels would require minimal changes to their production processes and that most employees would be retained. DOE estimates that there could be a more significant loss of domestic employment at TSLs 2, 3, and 4 due to the fact that these TSLs require condensing technology for gas-fired equipment classes. The lower bound of employment under amended standards assumes manufacturers choose to lay off some employees who work on their lower-efficiency, commodity products. At these TSLs, CWH manufacturers could also choose to source more components from overseas, limiting their need for production employees. To derive the lower bound of direct employment under amended standards, DOE estimated the percentage of CWH models that manufacturers would have to redesign at each TSL and assumed

[119] U.S. Census Bureau, Annual Survey of Manufacturers: General Statistics: Statistics for Industry Groups and Industries (2013) (Available at *http://factfinder.census.gov/faces/tableservices/jsf/pages/productview.xhtml?pid=ASM_2013_31GS101&prodType=table*).

domestic direct employment in the industry would decline by an equal proportion. This is intended to serve as a conservative assumption and represents the lower bound of a range of potential direct employment levels in the CWH industry under 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 NOPR TSD.

Issue 32: DOE seeks comment on its assessment of amended standards' potential impacts on direct employment.

c. Impacts on Manufacturing Capacity

Based on manufacturer feedback, DOE estimates that the average CWH equipment manufacturer's current production is running at approximately 60-percent capacity. Most manufacturers stated in interviews that they generally did not anticipate production capacity constraints associated with this rulemaking. Some noted that condensing equipment is generally more labor-intensive and takes longer to build; however, most agreed they could increase capacity by implementing a second shift with the current machinery they have, or by expanding production capacity. Some manufacturers did express concerns about engineering and laboratory resources if standards were set at a high level. However, given the compliance period, DOE believes that because most manufacturers already make equipment that meets the efficiency levels proposed in this NOPR, manufacturers would have time to redesign their product lines and production processes.

Issue 33: DOE seeks comment on its assessment of amended standards' potential impacts on manufacturing capacity.

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 13 domestic manufacturers in the CWH equipment industry that qualify as small businesses. For a discussion of the impacts on the small manufacturer subgroup, see the regulatory flexibility analysis in section VI.B of this notice and chapter 12 of the NOPR TSD.

e. Cumulative Regulatory Burden

While any one regulation may not impose a significant burden on manufacturers, the combined effects of recent 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 energy conservation standards for commercial equipment.

For the cumulative regulatory burden analysis, DOE looks at other regulations that could affect CWH equipment manufacturers that will take effect approximately three years before or after the 2019 compliance date of amended energy conservation standards for these equipment types. In interviews, manufacturers cited Federal regulations on equipment other than CWH equipment that contribute to their cumulative regulatory burden. The compliance years and expected industry conversion costs of relevant amended energy conservation standards are indicated in Table V.26.

TABLE V.26—COMPLIANCE DATES AND EXPECTED CONVERSION EXPENSES OF FEDERAL ENERGY CONSERVATION STANDARDS AFFECTING THE COMMERCIAL WATER HEATING INDUSTRY

Federal energy conservation standards	Approximate compliance date	Estimated total industry conversion expense
Commercial Packaged Air-Conditioning and Heating Equipment 81 FR 2420 (January 15, 2016).	2018 and 2023*	$520.8M (*2014$*).
Residential Furnace Fans 79 FR 38129 (July 3, 2014)	2019	$40.6M (*2013$*).
Residential Boilers 81 FR 2320 (January 15, 2016)	2021	$2.5M (*2014$*).
Commercial Packaged Boilers**	2020	TBD.
Residential Furnaces 80 FR 13120 (March 12, 2015) (NOPR)	2021	$55M (*2013$*).
Direct Heating Equipment/Pool Heaters**	2021	TBD.
Residential Water Heaters**	2021	TBD.

*This rule has multiple compliance dates.

**The NOPR and final rule for this energy conservation standard have not been published. The compliance date and analysis of conversion costs are estimates and have not been finalized at this time.

In addition to Federal energy conservation standards, DOE identified another regulatory burden that would affect manufacturers of CWH equipment:

Environmental Protection Agency (EPA) Significant New Alternatives Policy (SNAP) Program

Several manufacturers raised concerns in interviews about EPA's SNAP program and, in particular, a proposed rule to modify the listings for certain hydrofluorocarbons in various end-uses in the aerosols, refrigeration and air conditioning, and foam blowing sectors. 79 FR 46126 (August 6, 2014). On July 20, 2015, the EPA published a final rule under the SNAP program that adopts modifications similar to those outlined in the August 6, 2014 proposed rule. 80 FR 42870, 42923–24. Specifically, the final rule changed the status of several hydrofluorocarbons to unacceptable for use as foam blowing agents beginning January 1, 2020. Several manufacturers of CWH equipment use these materials (*i.e.,* HFC–245fa) as blowing agents to insulate their CWH equipment. DOE acknowledges that the EPA ban on these substances will impact the materials used by some CWH equipment manufacturers, which could require them to alter the design of certain equipment.

Issue 34: DOE requests comment on whether the classification of unacceptable blowing agents in the EPA's SNAP final rule will affect the insulating properties of foam insulation used in CWH equipment analyzed in this NOPR. Specifically, DOE seeks data that show the difference in thermal resistivity (*i.e.,* R-value per inch) between insulation currently used in storage water heaters and insulation that would be compliant with the regulations amended in the SNAP final rule, if currently used blowing agents are classified as unacceptable.

3. National Impact Analysis

a. Significance of Energy Savings

For each TSL, DOE projected energy savings for CWH equipment shipped in the 30-year period that begins in the year of anticipated compliance with amended standards (2019–2048). The savings are measured over the entire lifetime of equipment shipped in the 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.

Table V.27 presents the estimated primary energy savings for each considered TSL, and Table V.28 presents the estimated FFC energy savings for each TSL. The approach for estimating national energy savings is further described in section IV.H. Table V.29 shows cumulative primary national energy savings by TSL as a percentage of the no-new-standards-case primary energy usage.

TABLE V.27—CUMULATIVE NATIONAL PRIMARY ENERGY SAVINGS FOR CWH EQUIPMENT TRIAL STANDARD LEVELS FOR UNITS SHIPPED IN 2019–2048

[Quads]

Equipment class	Trial standard level *			
	TSL 1	TSL 2	TSL 3	TSL 4
Commercial gas-fired storage water heaters and gas-fired storage-type instantaneous water heaters	0.160	0.505	0.716	0.924
Residential-duty gas-fired storage water heaters	0.024	0.069	0.069	0.102
Gas-fired instantaneous water heaters and hot water supply boilers	0.179	0.661	0.772	0.888
Tankless water heaters	0.009	0.048	0.057	0.066
Hot water supply boilers	0.169	0.613	0.715	0.822
Electric storage water heaters	0.048	0.048	0.048	0.048
Total	0.410	1.282	1.604	1.961

* **Note:** Components may not sum to total due to rounding.

TABLE V.28—CUMULATIVE NATIONAL FULL-FUEL-CYCLE ENERGY SAVINGS FOR CWH EQUIPMENT TRIAL STANDARD LEVELS FOR UNITS SHIPPED IN 2019–2048

[Quads]

Equipment class	Trial standard level *			
	TSL 1	TSL 2	TSL 3	TSL 4
Commercial gas-fired storage water heaters and gas-fired storage-type instantaneous water heaters	0.179	0.569	0.805	1.038
Residential-duty gas-fired storage water heaters	0.027	0.078	0.078	0.115
Gas-fired instantaneous water heaters and hot water supply boilers	0.200	0.741	0.865	0.996
Tankless water heaters	0.011	0.054	0.064	0.074
Hot water supply boilers	0.190	0.687	0.801	0.921
Electric storage water heaters	0.050	0.050	0.050	0.050
Total	0.457	1.438	1.798	2.199

* **Note:** Components may not sum to total due to rounding.

TABLE V.29—CUMULATIVE PRIMARY NATIONAL ENERGY SAVINGS BY TSL AS A PERCENTAGE OF CUMULATIVE NO-NEW-STANDARDS-CASE ENERGY USAGE OF CWH EQUIPMENT SHIPPED IN 2019–2048

Equipment class	No-new-standards-case energy usage (quads)	TSL savings as percent of no-new-standards-case usage *			
		TSL 1 (%)	TSL 2 (%)	TSL 3 (%)	TSL 4 (%)
Commercial gas-fired storage water heaters and gas-fired storage-type instantaneous water heaters	6.0	3	8	12	15
Residential-duty gas-fired storage water heaters	0.7	4	10	10	15
Gas-fired instantaneous water heaters and hot water supply boilers	7.2	2	9	11	12
Tankless water heaters	0.5	2	9	11	12

TABLE V.29—CUMULATIVE PRIMARY NATIONAL ENERGY SAVINGS BY TSL AS A PERCENTAGE OF CUMULATIVE NO-NEW-STANDARDS-CASE ENERGY USAGE OF CWH EQUIPMENT SHIPPED IN 2019–2048—Continued

Equipment class	No-new-standards-case energy usage (quads)	TSL savings as percent of no-new-standards-case usage *			
		TSL 1 (%)	TSL 2 (%)	TSL 3 (%)	TSL 4 (%)
Hot water supply boilers	6.7	3	9	11	12
Electric storage water heaters	5.9	1	1	1	1
Total	19.8	2	6	8	10

* **Note:** Components may not sum to total due to rounding.

Circular A–4 [120] requires agencies to present analytical results, including separate schedules of the monetized benefits and costs that show the type and timing of benefits and costs. Circular A–4 also directs agencies to consider the variability of key elements underlying the estimates of benefits and costs. For this rulemaking, DOE undertook a sensitivity analysis using 9 years, rather than 30 years, of 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.[121] The review timeframe established in EPCA is generally not synchronized with the equipment lifetime, equipment manufacturing cycles, or other factors specific to CWH equipment. Thus, such results are presented for informational purposes only and are not indicative of any change in DOE's analytical methodology. The full-fuel-cycle NES results based on a nine-year analytical period are presented in Table V.30. The impacts are counted over the lifetime of products shipped in 2019–2027.

TABLE V.30—CUMULATIVE FULL-FUEL-CYCLE NATIONAL ENERGY SAVINGS FOR TRIAL STANDARD LEVELS FOR COMMERCIAL WATER HEATING EQUIPMENT SHIPPED IN 2019–2027

[Quads]

Equipment class	Trial standard level *			
	TSL 1	TSL 2	TSL 3	TSL 4
Commercial gas-fired storage water heaters and gas-fired storage-type instantaneous water heaters	0.048	0.153	0.216	0.279
Residential-duty gas-fired storage water heaters	0.007	0.021	0.021	0.031
Gas-fired instantaneous water heaters and hot water supply boilers	0.053	0.197	0.230	0.264
Tankless water heaters	0.002	0.013	0.015	0.017
Hot water supply boilers	0.051	0.184	0.215	0.247
Electric storage water heaters	0.012	0.012	0.012	0.012
Total	0.121	0.382	0.479	0.586

* **Note:** Components may not sum to total due to rounding.

b. Net Present Value of Commercial Consumer Costs and Benefits

DOE estimated the cumulative NPV of the total costs and savings for commercial consumers that would result from the TSLs considered for CWH equipment. In accordance with OMB's guidelines on regulatory analysis,[122] DOE calculated NPV using both a 3-percent and a 7-percent real discount rate. Table V.31 and Table V.32 show the commercial consumer NPV results at 3-percent and 7-percent discount rates respectively for each TSL considered for the CWH equipment covered in this rulemaking. In each case, the impacts cover the lifetime of equipment shipped in 2019–2048. Results for all equipment classes using the EPCA baseline can be found in chapter 10 of the NOPR TSD.

[120] U.S. Office of Management and Budget, ''Circular A–4: Regulatory Analysis'' (Sept. 17, 2003) (Available at: *http://www.whitehouse.gov/omb/circulars_a004_a-4/*).

[121] EPCA requires DOE to review its standards at least once every 6 years, and requires, for certain equipment, a 3-year period after any new standard is promulgated before compliance is required, except that in no case may any new standards be required within 6 years of the compliance date of the previous standards. (42 U.S.C. 6313(a)(6)(C)) 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 commercial equipment, the compliance period is 5 years rather than 3 years.

[122] OMB Circular A–4, section E (Sept. 17, 2003) (Available at *http://www.whitehouse.gov/omb/circulars_a004_a-4*).

TABLE V.31—CUMULATIVE NET PRESENT VALUE OF COMMERCIAL CONSUMER BENEFIT FOR CWH EQUIPMENT TRIAL STANDARD LEVELS AT A 3-PERCENT DISCOUNT RATE FOR EQUIPMENT SHIPPED IN 2019–2048

[Billion 2014$]

Equipment class	Trial standard level*			
	TSL 1	TSL 2	TSL 3	TSL 4
Commercial gas-fired storage water heaters and gas-fired storage-type instantaneous water heaters	0.65	1.96	3.15	4.30
Residential-duty gas-fired storage water heaters	0.04	0.16	0.16	0.28
Gas-fired instantaneous water heaters and hot water supply boilers	0.84	2.78	3.30	3.83
Tankless water heaters	0.04	0.34	0.39	0.43
Hot water supply boilers	0.80	2.44	2.91	3.40
Electric storage water heaters	0.14	0.14	0.14	0.14
Total	1.68	5.04	6.75	8.55

* **Note:** Components may not sum to total due to rounding.

TABLE V.32—CUMULATIVE NET PRESENT VALUE OF COMMERCIAL CONSUMER BENEFIT FOR CWH EQUIPMENT TRIAL STANDARD LEVELS AT A 7-PERCENT DISCOUNT RATE FOR EQUIPMENT SHIPPED IN 2019–2048

[Billion 2014$]

Equipment class	Trial standard level*			
	TSL 1	TSL 2	TSL 3	TSL 4
Commercial gas-fired storage water heaters and gas-fired storage-type instantaneous water heaters	0.26	0.71	1.23	1.73
Residential-duty gas-fired storage water heaters	0.006	0.03	0.03	0.07
Gas-fired instantaneous water heaters and hot water supply boilers	0.26	0.80	0.96	1.13
Tankless water heaters	0.01	0.13	0.15	0.16
Hot water supply boilers	0.25	0.67	0.82	0.96
Electric storage water heaters	0.04	0.04	0.04	0.04
Total	0.57	1.58	2.26	2.96

* **Note:** Components may not sum to total due to rounding.

The NPV results based on the aforementioned nine-year analytical period are presented in Table V.33 and Table V.34. The impacts are counted over the lifetime of equipment shipped in 2019–2027. 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.33—CUMULATIVE NET PRESENT VALUE OF COMMERCIAL CONSUMER BENEFIT FOR CWH EQUIPMENT TRIAL STANDARD LEVELS AT A 3-PERCENT DISCOUNT RATE FOR EQUIPMENT SHIPPED IN 2019–2027

[Billion 2014$]

Equipment class	Trial standard level*			
	TSL 1	TSL 2	TSL 3	TSL 4
Commercial gas-fired storage water heaters and gas-fired storage-type instantaneous water heaters	0.19	0.41	0.78	1.13
Residential-duty gas-fired storage water heaters	0.01	0.00	0.00	0.04
Gas-fired instantaneous water heaters and hot water supply boilers	0.25	0.74	0.89	1.05
Tankless water heaters	0.01	0.07	0.09	0.10
Hot water supply boilers	0.24	0.67	0.80	0.95
Electric storage water heaters	0.04	0.04	0.04	0.04
Total	0.48	1.19	1.71	2.25

* **Note:** Components may not sum to total due to rounding.

TABLE V.34—CUMULATIVE NET PRESENT VALUE OF COMMERCIAL CONSUMER BENEFIT FOR CWH EQUIPMENT TRIAL STANDARD LEVELS AT A 7-PERCENT DISCOUNT RATE FOR EQUIPMENT SHIPPED IN 2019–2027

[Billion 2014$]

Equipment class	Trial standard level *			
	TSL 1	TSL 2	TSL 3	TSL 4
Commercial gas-fired storage water heaters and gas-fired storage-type instantaneous water heaters	0.10	0.20	0.43	0.64
Residential-duty gas-fired storage water heaters	−0.001	−0.01	−0.01	0.00
Gas-fired instantaneous water heaters and hot water supply boilers	0.11	0.30	0.37	0.43
Tankless water heaters	0.00	0.04	0.05	0.06
Hot water supply boilers	0.11	0.26	0.32	0.38
Electric storage water heaters	0.02	0.02	0.02	0.02
Total	0.23	0.50	0.80	1.10

* **Note:** Components may not sum to total due to rounding.

The results presented in this section reflect an assumption of no change in CWH equipment prices by efficiency level over the forecast period. For this NOPR, DOE conducted sensitivity analyses to examine NIA results with varying inputs. The main reason for assuming no change in CWH equipment prices was data limitations, and the same limitations made alternative price trends problematic as well, so in the sensitivity analyses, the high and low price trends were also assumed to be ‘‘no change’’ trends. Sensitivity analyses are described in appendix 10B of the NOPR TSD.

c. Indirect Impacts on Employment

DOE expects that amended energy conservation standards for CWH equipment would reduce energy costs for equipment owners, with the resulting net savings being redirected to other forms of economic activity. Those shifts in spending and economic activity could affect the demand for labor. As described in section IV.N, DOE used an input/output model of the U.S. economy to estimate indirect employment impacts of the TSLs that DOE considered in this rulemaking. DOE understands that there are uncertainties involved in projecting employment impacts, especially changes in the later years of the analysis. Therefore, DOE generated results for near-term time frames (2019–2025), where these uncertainties are reduced.

The results suggest that these 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 more detailed results about anticipated indirect employment impacts.

4. Impact on Utility or Performance of Equipment

DOE has tentatively concluded that the amended standards it is proposing in this NOPR would not lessen the utility or performance of CWH equipment.

5. Impact of Any Lessening of Competition

DOE has also considered any lessening of competition that is likely to result from new and amended standards. 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. (42 U.S.C. 6313(a)(6)(B)(ii)(V) and (C)(i))

To assist the Attorney General in making such determination, DOE has provided the Department of Justice (DOJ) with copies of this NOPR and the TSD for review. DOE will consider DOJ's comments on the proposed rule in preparing the final rule, and 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 those potential impacts. See the **ADDRESSES** section for information to send comments to DOJ.

6. Need of the Nation To Conserve Energy

An improvement in the energy efficiency of the equipment subject to this rule is likely to improve the security of the nation's energy system by reducing overall demand for energy. Reduced energy demand may also improve the reliability of the energy system. DOE evaluated the impact on national electric generating capacity for each considered TSL. Chapter 15 of the NOPR TSD provides more details of the TSLs' impact on the electricity and natural gas utilities.

Potential energy savings from the proposed amended standards for the considered CWH equipment classes could also produce environmental benefits in the form of reduced emissions of air pollutants and greenhouse gases associated with electricity production. Table V.35 provides DOE's estimate of cumulative emissions reductions projected to result from the TSLs considered in this rulemaking. The table includes both power sector emissions and upstream emissions. The upstream emissions were calculated using the multipliers discussed in section IV.K. DOE reports annual CO_2, NO_X, and Hg emissions reductions for each TSL in chapter 13 of the NOPR TSD.

TABLE V.35—CUMULATIVE EMISSIONS REDUCTION FOR POTENTIAL AMENDED STANDARDS FOR COMMERCIAL WATER HEATING EQUIPMENT SHIPPED IN 2019–2048

	TSL			
	1	2	3	4
Power Sector and Site Emissions *				
CO_2 (*million metric tons*)	22	68	85	104
NO_X (*thousand tons*)	30	97	121	148
Hg (*tons*)	0.01	0.004	0.004	0.005
N_2O (*thousand tons*)	0.08	0.16	0.20	0.24
CH_4 (*thousand tons*)	0.66	1.52	1.89	2.30
SO_2 (*thousand tons*)	2.02	1.36	1.57	1.82
Upstream Emissions				
CO_2 (*million metric tons*)	3	10	12	15
NO_X (*thousand tons*)	47	156	195	239
Hg (*tons*)	0.0001	0.00004	0.00004	0.00005
N_2O (*thousand tons*)	0.01	0.02	0.02	0.03
CH_4 (*thousand tons*)	279	934	1,170	1,432
SO_2 (*thousand tons*)	0.05	0.06	0.08	0.09
Total Emissions				
CO_2 (*million metric tons*)	25	78	98	119
NO_X (*thousand tons*)	77	252	316	386
Hg (*tons*)	0.01	0.004	0.004	0.005
N_2O (*thousand tons*)	0.08	0.18	0.22	0.26
N_2O (*thousand tons CO_2eq*) **	22	47	58	70
CH_4 (*thousand tons*)	279	936	1,172	1,434
CH_4 (*thousand tons CO_2eq*) **	7,821	26,197	32,812	40,149
SO_2 (*thousand tons*)	2.07	1.42	1.65	1.91

* Includes emissions from additional gas use of more-efficient CWH equipment.
** CO_2eq is the quantity of CO_2 that would have the same global warming potential (GWP).

As part of the analysis for this NOPR, DOE estimated monetary benefits likely to result from the reduced emissions of CO_2 and NO_X estimated for each of the TSLs considered for CWH equipment. As discussed in section IV.L, for CO_2, DOE used the most recent values for the SCC developed by an interagency process. The interagency group selected four sets of SCC values for use in regulatory analyses. Three sets are based on the average SCC from three integrated assessment models, at discount rates of 2.5 percent, 3 percent, and 5 percent. The fourth set, which represents the 95th-percentile SCC estimate across all three models at a 3-percent discount rate, is included to represent higher-than-expected impacts from temperature change further out in the tails of the SCC distribution. The four SCC values for CO_2 emissions reductions in 2015, expressed in 2014$, are $12.2 per metric ton, $40.0 per metric ton, $62.3 per metric ton, and $117 per metric ton. The values for later years are higher due to increasing emissions-related costs as the magnitude of projected climate change increases.

Table V.36 presents the global value of CO_2 emissions reductions at each TSL. DOE calculated domestic values as a range from 7 percent to 23 percent of the global values, and these results are presented in chapter 14 of the NOPR TSD.

TABLE V.36—GLOBAL PRESENT VALUE OF CO_2 EMISSIONS REDUCTION FOR POTENTIAL STANDARDS FOR CWH EQUIPMENT SHIPPED IN 2019–2048

TSL	SCC scenario *			
	Million 2014$			
	5% discount rate, average	3% discount rate, average	2.5% discount rate, average	3% discount rate, 95th percentile
Power Sector and Site Emissions **				
1	145	680	1,085	2,073
2	441	2,081	3,327	6,348
3	555	2,612	4,173	7,967
4	682	3,202	5,113	9,765
Upstream Emissions				
1	19	90	143	273

TABLE V.36—GLOBAL PRESENT VALUE OF CO_2 EMISSIONS REDUCTION FOR POTENTIAL STANDARDS FOR CWH EQUIPMENT SHIPPED IN 2019–2048—Continued

TSL	SCC scenario* Million 2014$			
	5% discount rate, average	3% discount rate, average	2.5% discount rate, average	3% discount rate, 95th percentile
2	63	297	474	905
3	79	373	596	1,138
4	98	458	731	1,396
Total Emissions				
1	164	769	1,228	2,346
2	504	2,378	3,801	7,253
3	635	2,985	4,769	9,105
4	780	3,660	5,844	11,161

* For each of the four cases, the corresponding SCC value for emissions in 2015 is $12.2, $40.0, $62.3 and $117 per metric ton (2014$). The values are for CO_2 only (*i.e.,* no CO_2eq of other greenhouse gases).
** Includes site emissions associated with use of gas-fired CWH equipment.

DOE is well aware that scientific and economic knowledge continues to evolve rapidly regarding the contribution of CO_2 and other greenhouse gas (GHG) emissions to changes in the future global climate and the potential resulting damages to the world economy. Thus, any value placed in this rulemaking on reducing CO_2 emissions is subject to change. DOE, together with other Federal agencies, will continue to review various 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. However, consistent with DOE's legal obligations, and taking into account the uncertainty involved with this particular issue, DOE has included in this NOPR the most recent values and analyses resulting from the interagency review process.

DOE also estimated the cumulative monetary value of the economic benefits associated with NO_X emissions reductions anticipated to result from the considered TSLs for amended standards for the CWH equipment that is the subject of this NOPR. The dollar-per-ton values that DOE used are discussed in section IV.L. Table V.37 presents the cumulative present value for NO_X emissions for each TSL calculated using the average dollar-per-ton values and 7-percent and 3-percent discount rates. This table presents values that use the low dollar-per-ton values, which reflect DOE's primary estimate. Results that reflect the range of NO_X dollar-per-ton values are presented in Table V.37. Detailed discussions on NO_X emissions reductions are available in chapter 14 of the NOPR TSD.

TABLE V.37—PRESENT VALUE OF NO_X EMISSIONS REDUCTION FOR POTENTIAL STANDARDS FOR CWH EQUIPMENT

TSL	Million 2014$	
	3% discount rate	7% discount rate
Power Sector and Site Emissions*		
1	93	36
2	294	112
3	371	142
4	456	176
Upstream Emissions		
1	143	55
2	475	181
3	599	231
4	737	285
Total Emissions		
1	236	91
2	769	294
3	970	373
4	1,193	461

* Includes site emissions associated with use of gas-fired CWH equipment.

The NPV of the monetized benefits associated with emissions reductions can be viewed as a complement to the NPV of the consumer savings calculated for each TSL considered in this rulemaking. Table V.38 presents the NPV values that result from adding the estimates of the potential economic benefits resulting from reduced CO_2 and NO_X emissions in each of four valuation scenarios to the NPV of consumer savings calculated for each TSL for CWH equipment considered in this rulemaking, at both a 7-percent and 3-percent discount rate. The CO_2 values used in the columns correspond to the four sets of SCC values discussed in section IV.L.1.

TABLE V.38—CWH EQUIPMENT TSLS: NET PRESENT VALUE OF CONSUMER SAVINGS COMBINED WITH NET PRESENT VALUE OF MONETIZED BENEFITS FROM CO_2 AND NO_X EMISSIONS REDUCTIONS

TSL	Consumer NPV at 3% discount rate added with: (billion 2014$)			
	SCC at 5% discount rate* and 3% low NO_X value	SCC at 3% discount rate* and 3% low NO_X value	SCC at 2.5% discount rate* and 3% low NO_X value	95th percentile SCC at 3% discount rate* and 3% low NO_X value
1	2.105	2.711	3.170	4.287
2	6.398	8.272	9.695	13.147
3	8.463	10.814	12.598	16.933
4	10.656	13.537	15.721	21.038
TSL	Consumer NPV at 7% discount rate added with: (billion 2014$)			
	SCC at 5% discount rate* and 7% low NO_X value	SCC at 3% discount rate* and 7% low NO_X value	SCC at 2.5% discount rate* and 7% low NO_X value	95th percentile SCC at 3% discount rate* and 7% low NO_X value
1	0.831	1.436	1.895	3.013
2	2.403	4.277	5.700	9.152
3	3.302	5.653	7.437	11.772
4	4.242	7.123	9.307	14.624

* The interagency group selected four sets of SCC values for use in regulatory analyses. Three sets of values are based on the average SCC from the integrated assessment models, at discount rates of 5, 3, and 2.5 percent. For example, for 2015 emissions, these values are $12.2/metric ton, $40.0/metric ton, and $62.3/metric ton, in 2014$, respectively. The fourth set ($117 per metric ton in 2014$ for 2015 emissions), which represents the 95th percentile SCC estimate across all three models at a 3-percent discount rate, is included to represent higher-than-expected impacts from temperature change further out in the tails of the SCC distribution. The SCC values are emission year specific. For NO_X emissions, the 3 and 7-percent values are discussed in more detail in section IV.L.2.

In considering the above results, two issues are relevant. First, the national operating cost savings are domestic U.S. commercial consumer monetary savings that occur as a result of market transactions, while the value of CO_2 reductions is based on a global value. Second, the assessments of operating cost savings and the SCC are performed with different methods that use quite different time frames for analysis. The national operating cost savings is measured for the lifetime of products shipped in 2019–2048. Because CO_2 emissions have a very long residence time in the atmosphere,[123] the SCC values in future years reflect future CO_2 emissions impacts that continue beyond 2100 through 2300.

7. Other Factors

The Secretary of Energy, in determining whether a standard is economically justified, may consider any other factors that the Secretary deems to be relevant. (42 U.S.C. 6313(a)(6)(B)(ii)(VII) and (C)(i)) No other factors were considered in this analysis.

C. Proposed Standards

To adopt national standards more stringent than the current standards for CWH equipment, DOE must determine that such action would result in significant additional conservation of energy and 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 (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 additional amount of energy.

To aid the reader in understanding 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 commercial consumers who may be disproportionately affected by a national standard and impacts on employment.

1. Benefits and Burdens of Trial Standard Levels Considered for CWH Equipment

Table V.39, Table V.40, and Table V.41 summarize the quantitative impacts estimated for each TSL for CWH equipment. The national impacts are measured over the lifetime of CWH equipment shipped in the 30-year period that begins in the year of compliance with amended standards (2019–2048). The energy savings, emissions reductions, and value of emissions reductions refer to full-fuel-cycle results.

[123] The atmospheric lifetime of CO_2 is estimated of the order of 30–95 years. Jacobson, MZ, "Correction to 'Control of fossil-fuel particulate black carbon and organic matter, possibly the most effective method of slowing global warming,' " *J. Geophys. Res.* 110. pp. D14105 (2005).

TABLE V.39—SUMMARY OF ANALYTICAL RESULTS FOR CWH EQUIPMENT: NATIONAL IMPACTS

Category	TSL 1	TSL 2	TSL 3	TSL 4
National FFC Energy Savings (*quads*)	0.457	1.438	1.798	2.199.
NPV of Commercial Consumer Benefits (billion 2014$)				
3% discount rate	1.68	5.04	6.75	8.55.
7% discount rate	0.57	1.58	2.26	2.96.
Manufacturer Impacts				
Industry NPV (*2014$ million*):				
No-new-standards case INPV = 176.2	171.5 to 177.4	158.8 to 187.8	152.8 to 185.0	128.6 to 166.6.
Change in Industry NPV (2014$ million)	(4.7) to 1.2	(17.4) to 11.6	(23.4) to 8.8	(47.6) to (9.7).
Change in Industry NPV (%)	(2.7) to 0.7	(9.9) to 6.6	(13.3) to 5.0	(27.0) to (5.5).
Cumulative Emissions Reduction (Total FFC Emissions)				
CO_2 (*million metric tons*)	25.08	78.06	97.63	119.34.
NO_X (*thousand tons*)	76.93	252.35	315.95	386.48.
Hg (tons)	0.01	0.004	0.004	0.005.
N_2O (*thousand tons*)	0.08	0.18	0.22	0.26.
N_2O (*thousand tons CO_2eq*)	22.11	46.63	57.76	70.14.
CH_4 (*thousand tons*)	279	936	1,172	1,434.
CH_4 (*thousand tons CO_2eq*) *	7,821	26,197	32,812	40,149.
SO_2 (*thousand tons*)	2.07	1.42	1.65	1.91.
Value of Emissions Reduction (Total FFC Emissions)				
CO_2 (*2014$ million*) **	164 to 2,346	504 to 7,253	635 to 9,105	780 to 11,161.
NO_X—3% discount rate (*2014$ million*)	236 to 524	769 to 1,703	970 to 2,148	1,193 to 2,643.
NO_X—7% discount rate (*2014$ million*)	91 to 203	294 to 655	373 to 833	461 to 1,030.

* CO_2eq is the quantity of CO_2 that would have the same global warming potential (GWP).
** Range of the economic value of CO_2 reductions is based on estimates of the global benefit of reduced CO_2 emissions.
Note: Parentheses indicate negative values.

TABLE V.40—SUMMARY OF ANALYTICAL RESULTS FOR CWH EQUIPMENT: NPV OF COMMERCIAL CONSUMER BENEFITS BY EQUIPMENT CLASS

Equipment class	Discount rate (%)	Trial standard level * Billion 2014$			
		1	2	3	4
Commercial gas-fired storage water heaters and gas-fired storage-type instantaneous water heaters	3	0.654	1.958	3.154	4.302
	7	0.256	0.708	1.231	1.727
Residential-duty gas-fired storage water heaters	3	0.044	0.163	0.163	0.282
	7	0.006	0.026	0.026	0.067
Gas-fired instantaneous water heaters and hot water supply boilers	3	0.842	2.778	3.296	3.832
	7	0.265	0.805	0.964	1.128
Tankless water heaters	3	0.038	0.340	0.387	0.433
	7	0.013	0.130	0.147	0.163
Hot water supply boilers	3	0.804	2.438	2.909	3.399
	7	0.251	0.674	0.817	0.964
Electric storage water heaters	3	0.138	0.138	0.138	0.138
	7	0.042	0.042	0.042	0.042
Total—All Classes	3	1.679	5.037	6.750	8.553
	7	0.568	1.580	2.263	2.963

* **Note:** Components may not sum to total due to rounding.

TABLE V.41—SUMMARY OF ANALYTICAL RESULTS FOR CWH EQUIPMENT: COMMERCIAL CONSUMER IMPACTS

	TSL 1	TSL 2	TSL 3	TSL 4
Commercial Consumer Mean LCC Savings (2014$)				
Commercial gas-fired storage water heaters	219	317	794	1,252
Residential-duty gas-fired storage water heaters	537	14	14	241
Gas-fired instantaneous water heaters and hot water supply boilers	891	2,944	3,488	4,046
Gas-fired tankless water heaters	86	1,009	1,119	1,224
Gas-fired hot water supply boilers	1,245	3,794	4,528	5,285

TABLE V.41—SUMMARY OF ANALYTICAL RESULTS FOR CWH EQUIPMENT: COMMERCIAL CONSUMER IMPACTS—Continued

	TSL 1	TSL 2	TSL 3	TSL 4
Electric storage water heaters	47	47	47	47
Commercial Consumer Simple PBP (years)				
Commercial gas-fired storage water heaters	3.8	5.7	4.3	3.8
Residential-duty gas-fired storage water heaters	10.5	11.9	11.9	10.2
Gas-fired instantaneous water heaters and hot water supply boilers	3.6	5.8	5.6	5.6
Gas-fired tankless water heaters	2.9	Immediate	Immediate	Immediate
Gas-fired hot water supply boilers	3.6	6.7	6.4	6.3
Electric storage water heaters	6.5	6.5	6.5	6.5
Distribution of Commercial Consumer LCC Impacts (Net Cost %)				
Commercial gas-fired storage water heaters	8	30	24	21
Residential-duty gas-fired storage water heaters	32	42	42	36
Gas-fired instantaneous water heaters and hot water supply boilers	14	27	26	27
Gas-fired tankless water heaters	11	38	35	33
Gas-fired hot water supply boilers	15	22	22	24
Electric storage water heaters	14	14	14	14

Note: Parentheses indicate negative values. Immediate payback can result from a decrease in installation cost that is greater than the incremental increase in equipment cost.

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 (*e.g.,* an inefficient ventilation fan in a new building or the delayed replacement of a water pump); (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 (*e.g.,* renter versus building owner, builder versus home buyer). Other literature indicates that with 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. This undervaluation suggests that regulation that promotes energy efficiency can produce significant net private gains (as well as producing social gains by, for example, reducing pollution).

While DOE is not prepared at present to provide a fuller quantifiable framework for estimating the benefits and costs of changes in consumer purchase decisions due to an amended energy conservation standard, DOE is committed to developing a framework that can support empirical quantitative tools for improved assessment of the consumer welfare impacts of appliance standards. DOE has posted a paper that discusses the issue of consumer welfare impacts of appliance energy efficiency standards, and potential enhancements to the methodology by which these impacts are defined and estimated in the regulatory process.[124] DOE welcomes comments on how to more fully assess the potential impact of energy conservation standards on consumer choice and methods to quantify this impact in its regulatory analysis.

First, DOE considered TSL 4, which corresponds to the max-tech level for all the equipment classes and offers the potential for the highest cumulative energy savings through the analysis period from 2019 through 2048. The estimated energy savings from TSL 4 are 2.2 quads of energy, an amount DOE considers significant. TSL 4 has an estimated NPV of commercial consumer benefit of $2.96 billion using a 7-percent discount rate, and $8.55 billion using a 3-percent discount rate.

The cumulative emissions reductions at TSL 4 are 119 million metric tons of CO_2, 1.9 thousand tons of SO_2, 386 thousand tons of NO_X, 0.005 tons of Hg, 1,434 thousand tons of CH_4, and 0.3 thousand tons of N_2O. The estimated monetary value of the CO_2 emissions reductions at TSL 4 ranges from $780 million to $11,161 million.

At TSL 4, the average LCC savings range from $47 to $4,046, and the simple PBP ranges from 3.8 to 10.2 years, depending on equipment class. The fraction of commercial consumers incurring a net LCC cost ranges from 14 percent for electric storage water heaters to 36 percent for residential-duty gas-fired storage water heaters.

At TSL 4, the projected change in INPV ranges from a decrease of $47.6 million to a decrease of $9.7 million. If the lower bound of the range of impacts is reached, as DOE expects, TSL 4 could result in a net loss of up to 27.0 percent in INPV for manufacturers of covered CWH equipment.

Accordingly, the Secretary tentatively concludes that at TSL 4 for CWH equipment, the benefits of energy savings, positive NPV of commercial consumer benefits, emission reductions, and the estimated monetary value of the CO_2 and NO_X emissions reductions would be outweighed by the large reduction in INPV at TSL 4. Consequently, DOE has tentatively concluded that TSL 4 is not economically justified.

Next DOE considered TSL 3, which would save an estimated 1.8 quads of energy, an amount DOE considers significant. TSL 3 has an estimated NPV of commercial consumer benefit of $2.26 billion using a 7-percent discount rate, and $6.75 billion using a 3-percent discount rate.

The cumulative emissions reductions at TSL 3 are 98 million metric tons of CO_2, 1.6 thousand tons of SO_2, 316

[124] Sanstad, A., *Notes on the Economics of Household Energy Consumption and Technology Choice,* Lawrence Berkeley National Laboratory (2010) (Available at: *<www1.eere.energy.gov/buildings/appliance_standards/pdfs/consumer_ee_theory.pdf>*).

thousand tons of NO_X, 0.004 tons of Hg, 1,172 thousand tons of CH_4, and 0.2 thousand tons of N_2O. The estimated monetary value of the CO_2 emissions reductions at TSL 3 ranges from $635 million to $9,105 million.

At TSL 3, the average LCC savings ranges from $47 to $3,488, and the simple PBP ranges from 4.3 to 11.9 years, depending on equipment class. The fraction of commercial consumers incurring a net LCC cost ranges from 14 percent for electric storage water heaters to 42 percent for residential-duty gas-fired storage water heaters.

At TSL 3, the projected change in INPV ranges from a decrease of $23.4 million to an increase of $8.8 million. At TSL 3, DOE recognizes the risk of negative impacts if manufacturers' expectations concerning reduced profit margins are realized. If the lower bound of the range of impacts is reached, as DOE expects, TSL 3 could result in a net loss of up to 13.3 percent in INPV for manufacturers of covered CWH equipment.

After carefully considering the analytical results and weighing the benefits and burdens, DOE has tentatively concluded that at TSL 3 for CWH equipment, the benefits of energy savings, positive NPV of commercial consumer benefit, positive impacts on commercial consumers through reduced life-cycle costs, emissions reductions, and the estimated monetary value of emissions reductions would outweigh the potential reductions in INPV for manufacturers. Accordingly, the Secretary of Energy has tentatively concluded that TSL 3 would save a significant additional amount of energy and is technologically feasible and economically justified.

Therefore, based upon the above considerations, DOE proposes to adopt amended energy conservation standards for commercial water heating equipment at TSL 3. Table V.42 and Table V.43 present the proposed energy conservation standards for commercial water heating equipment.

TABLE V.42—PROPOSED AMENDED ENERGY CONSERVATION STANDARDS FOR COMMERCIAL WATER HEATING EQUIPMENT EXCEPT FOR RESIDENTIAL-DUTY COMMERCIAL WATER HEATERS

[TSL 3]

Equipment class **	Specifications	Energy conservation standards *	
		Minimum thermal efficiency (%)	Maximum standby loss
Electric storage water heaters	All	N/A	$0.84 \times [0.30+27/V_r]$ (%/h).
Gas-fired storage water heaters	All †	95	$0.63 \times [Q/800 + 110(V_r)^{1/2}]$ (*Btu/h*).
Gas-fired instantaneous water heaters and hot water supply boilers:			
Instantaneous water heaters (other than storage-type) and hot water supply boilers.	<10 gal	94	N/A.
Instantaneous water heaters (other than storage-type) and hot water supply boilers.	≥10 gal	94	$Q/800 + 110(V_r)^{1/2}$ (*Btu/h*).
Storage-type instantaneous water heaters	≥10 gal	95	$0.63 \times [Q/800 + 110(V_r)^{1/2}]$ (*Btu/h*).

* V_r is the rated volume in gallons. Q is the fuel input rate in Btu/h.
** DOE proposes a new equipment class for storage-type instantaneous water heaters. This class of equipment is similar to storage water heaters in design, cost, and application. However, it has a ratio of input capacity to storage volume greater than or equal to 4,000 Btu/h per gallon of water stored; therefore, it is classified as an instantaneous water heater by EPCA's definition at 42 U.S.C. 6311(12)(B). Because of the similarities to storage water heaters, DOE grouped these two equipment classes together in its analyses for this NOPR. Storage-type instantaneous water heaters are further discussed in section IV.A.2.a.
† These standards only apply to commercial water heating equipment that does not meet the definition of "residential-duty commercial water heater." See Table V.43 for energy conservation standards proposed for residential-duty commercial water heaters.

TABLE V.43—PROPOSED ENERGY CONSERVATION STANDARDS FOR RESIDENTIAL-DUTY COMMERCIAL WATER HEATING EQUIPMENT

[TSL 3]

Equipment class	Specification *	Draw pattern	Uniform energy factor **
Gas-fired Storage †	>75 kBtu/h and	Very Small	$0.4618 - (0.0010 \times V_r)$.
	≤105 kBtu/h and	Low	$0.6626 - (0.0009 \times V_r)$.
	≤120 gal and	Medium	$0.6996 - (0.0007 \times V_r)$.
	≤180 °F	High	$0.7311 - (0.0006 \times V_r)$.

* To be classified as a residential-duty commercial 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.
** V_r is the rated storage volume.
† Energy conservation standards for residential-duty commercial gas-fired storage water heaters were converted from the thermal efficiency and standby loss metrics to the new UEF metric using conversion factors proposed by DOE in the April 2015 NOPR for all four draw patterns: Very small, low, medium, and high. 80 FR 20116, 20143 (April 14, 2015).

2. Summary of Benefits and Costs (Annualized) of the Proposed Standards

The benefits and costs of the proposed standards in this document can also be expressed in terms of annualized values. The annualized monetary values are the sum of: (1) The annualized national economic value (expressed in 2014$) of the benefits from operating equipment that meets the proposed standards (consisting primarily of operating cost savings from using less energy, minus increases in equipment purchase costs, which is another way of representing commercial consumer NPV), and (2) the annualized monetary value of the benefits of emission reductions, including CO_2 emission reductions.[125] The value of the CO_2 reductions, otherwise known as the Social Cost of Carbon (SCC), is calculated using a range of values per metric ton of CO_2 developed by a recent interagency process.

The national operating savings are domestic private U.S. consumer monetary savings that occur as a result of purchasing these equipment. The national operating cost savings is measured for the lifetime of CWH equipment shipped in 2019–2048.

The CO_2 reduction is a benefit that accrues globally due to decreased domestic energy consumption that is expected to result from this rule. Because CO_2 emissions have a very long residence time in the atmosphere,[126] the SCC values in future years reflect future CO_2-emissions impacts that continue beyond 2100 through 2300.

Table V.44 shows the annualized benefit and cost values for the proposed standards for CWH equipment under TSL 3, expressed in 2014$. The results under the primary estimate are as follows.

Using a 7-percent discount rate for benefits and costs other than CO_2 reduction (for which DOE used a 3-percent discount rate along with the average SCC series that has a value of $40.0 per metric ton in 2015), the estimated cost of the CWH standards proposed in this document is $144 million per year in increased equipment costs, while the estimated benefits are $367 million per year in reduced equipment operating costs, $166 million per year from CO_2 reductions, and $37 million per year from reduced NO_X emissions. In this case, the annualized net benefit amounts to $427 million per year.

Using a 3-percent discount rate for benefits and costs and the average SCC series that has a value of $40.0 per metric ton in 2015, the estimated cost of the CWH standards proposed in this NOPR is $141 million per year in increased equipment costs, while the estimated benefits are $517 million per year in reduced operating costs, $166 million per year from CO_2 reductions, and $54 million per year in reduced NO_X emissions. In this case, the net benefit amounts to $597 million per year.

TABLE V.44—ANNUALIZED BENEFITS AND COSTS OF PROPOSED STANDARDS (TSL 3) FOR CWH EQUIPMENT *

	Discount rate	Million 2014$/year		
		Primary estimate *	Low net benefits estimate *	High net benefits estimate *
Benefits				
Commercial Consumer Operating Cost Savings *	7%	367	336	411.
	3%	517	465	588.
CO_2 Reduction (using mean SCC at 5% discount rate) **	5%	48	46	50.
CO_2 Reduction (using mean SCC at 3% discount rate) **	3%	166	159	176.
CO_2 Reduction (using mean SCC at 2.5% discount rate) **	2.5%	245	234	259.
CO_2 Reduction (using 95th percentile SCC at 3% discount rate) **.	3%	508	485	536.
NO_X Reduction †	7%	37	35	86.
	3%	54	52	126.
Total Benefits ††	7% plus CO_2 range	452 to 912	417 to 855	547 to 1,033.
	7%	571	530	673.
	3% plus CO_2 range	619 to 1,079	563 to 1,001	765 to 1,251.
	3%	737	676	890.
Costs				
Commercial Consumer Incremental Equipment Costs	7%	144	147	142.
	3%	141	144	138.
Net Benefits/Costs				
Total ††	7% plus CO_2 range	308 to 768	270 to 709	406 to 892.
	7%	427	383	531.
	3% plus CO_2 range	478 to 938	419 to 857	627 to 1,113.
	3%	597	532	752.

* This table presents the annualized costs and benefits associated with commercial water heating equipment shipped in 2019–2048. These results include benefits to commercial consumers that accrue after 2048 from the equipment shipped in 2019–2048. The Primary, Low Benefits, and High Benefits Estimates for operating cost savings utilize projections of energy prices and building growth (leading to higher shipments) from the *AEO 2015* Reference case, Low Estimate, and High Estimate, respectively. In addition, DOE used a constant price assumption as the default price projection; the cost to manufacture a given unit of higher efficiency neither increases nor decreases over time. The analysis of the price trends is described in section IV.F.2.a and appendix 10B of the NOPR TSD.

** The interagency group selected four sets of SCC values for use in regulatory analyses. Three sets of values are based on the average SCC from the integrated assessment models, at discount rates of 5, 3, and 2.5 percent. For example, for 2015 emissions, these values are $12.2/metric ton, $40.0/metric ton, and $62.3/metric ton, in 2014$, respectively. The fourth set ($117 per metric ton in 2014$ for 2015 emissions), which represents the 95th percentile of the SCC distribution calculated using SCC estimate across all three models at a 3-percent discount rate, is included to represent higher-than-expected impacts from temperature change further out in the tails of the SCC distribution. The SCC values are emission year specific. See section IV.L for more details.

[125] To convert the time-series of costs and benefits into annualized values, DOE calculated a present value in 2015, 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 (2020, 2030, *etc.*), and then discounted the present value from each year to 2015. 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. 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.

[126] The atmospheric lifetime of CO_2 is estimated to be on the order of 30–95 years. Jacobson, MZ, ''Correction to 'Control of fossil-fuel particulate black carbon and organic matter, possibly the most effective method of slowing global warming,' '' *J. Geophys. Res.* 110. pp. D14105 (2005).

† The $/ton values used for NO_X are described in section IV.L. DOE estimated the monetized value of NO_X emissions reductions using benefit per ton estimates from the Regulatory Impact Analysis titled, "Proposed Carbon Pollution Guidelines for Existing Power Plants and Emission Standards for Modified and Reconstructed Power Plants," published in June 2014 by EPA's Office of Air Quality Planning and Standards. (Available at *www3.epa.gov/ttnecas1/regdata/RIAs/111dproposalRIAfinal0602.pdf.*) See section IV.L.2 for further discussion. Note that the agency is presenting a national benefit-per-ton estimate for particulate matter emitted from the Electric Generating Unit sector based on an estimate of premature mortality derived from the ACS study (Krewski et al. 2009). If the benefit-per-ton estimates were based on the Six Cities study (Lepuele et al. 2011), the values would be nearly two-and-a-half times larger. Because of the sensitivity of the benefit-per-ton estimate to the geographical considerations of sources and receptors of emissions, DOE intends to investigate refinements to the agency's current approach of one national estimate by assessing the regional approach taken by EPA's Regulatory Impact Analysis for the Clean Power Plan Final Rule.

†† Total benefits for both the 3-percent and 7-percent cases are derived using the series corresponding to SCC value of $40.0/metric ton . In the rows labeled "7% plus CO_2 range" and "3% plus CO_2 range," the operating cost and NO_X benefits are calculated using the labeled discount rate, and those values are added to the full range of CO_2 values.

VI. Procedural Issues and Regulatory Review

A. Review Under Executive Orders 12866 and 13563

Section 1(b)(1) of Executive Order 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 this document's proposed standards address are as follows:

(1) Insufficient information and the high costs of gathering and analyzing relevant information lead some commercial 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 of operating the equipment.

(3) There are external benefits resulting from improved energy efficiency of CWH equipment that are not captured by the users of such equipment. These benefits include externalities related to public health, environmental protection, and energy security that are not reflected in energy prices, such as reduced air pollutants and emissions of 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 regulatory action proposed in this document is a ''significant regulatory action'' under section (3)(f) of Executive Order 12866. Accordingly, pursuant to section 6(a)(3)(B) of the Executive 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.

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 Executive Order 12866. Accordingly, pursuant to section 6(a)(3)(C) of the Executive Order, DOE has provided to OIRA a regulatory impact analysis (RIA), 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 prepared pursuant to Executive Order 12866 can be found in the technical support document for this rulemaking. These documents have also been included in the rulemaking record.

DOE has also reviewed this regulation pursuant to Executive Order 13563, issued on January 18, 2011. 76 FR 3281 (Jan. 21, 2011). Executive Order 13563 is supplemental to and explicitly reaffirms the principles, structures, and definitions governing regulatory review established in Executive Order 12866. To the extent permitted by law, agencies are required by Executive Order 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 Executive Order 13563 requires agencies to use the best available techniques to quantify anticipated present and future benefits and costs as accurately as possible. In its guidance, the Office of Information and Regulatory Affairs 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, DOE believes that 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) 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 Web site (*http://energy.gov/gc/office-general-counsel*). DOE has prepared the following IRFA for the equipment that is the subject of this rulemaking.

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. 65 FR 30836, 30848 (May 15, 2000), as amended at 77 FR 49991, 50000, 50011 (August 20, 2012) and codified at 13 CFR part 121. The size standards are listed by North American Industry Classification System (NAICS) code and industry description and are available at *http://www.sba.gov/category/navigation-structure/contracting/contracting-officials/small-business-size-standards*. Manufacturing of CWH equipment is classified under NAICS 333318, ''Other Commercial and Service Industry Machinery Manufacturing.'' The SBA sets a threshold of 1,000 employees or less for an entity to be considered as a small business for this category.

1. Description and Estimated Number of Small Entities Regulated

To estimate the number of companies that could be small business manufacturers of equipment covered by this rulemaking, DOE conducted a market survey using publicly-available information to identify potential small manufacturers. DOE's research involved industry trade association membership directories (including AHRI [127]), public databases (*e.g.,* the California Energy Commission Appliance Efficiency Database [128] and DOE's Compliance Certification Database [129]), individual company Web sites, and market research tools (*e.g.,* Hoovers reports [130]) to create a list of companies that manufacture or sell equipment covered by this rulemaking. DOE also asked stakeholders and industry representatives if they were aware of any other small manufacturers during manufacturer interviews. DOE reviewed publicly-available data and contacted select companies on its list, as necessary, to determine whether they met the SBA's definition of a small business manufacturer of covered CWH equipment. DOE screened out companies that do not offer equipment covered by this rulemaking, do not meet the definition of a ''small business,'' or are foreign owned and operated.

DOE identified 25 manufacturers of commercial water heaters sold in the U.S. Of these 25, DOE identified 13 as domestic small businesses. Twelve of the 13 domestic small businesses are original equipment manufacturers (OEMs) of CWH equipment covered by this rulemaking, while one rebrands equipment manufactured by other OEMs.

Before issuing this NOPR, DOE attempted to contact all the small business manufacturers of CWH equipment it had identified. Two of the small businesses agreed to take part in an MIA interview. DOE also obtained information about small business impacts while interviewing large manufacturers.

DOE estimates that small manufacturers control approximately 7 percent of the CWH market. Based on DOE's research, six small businesses are primarily boiler manufacturers that produce hot water supply boilers covered under this rulemaking. Two of these manufacturers primarily produce high-efficiency condensing equipment, while the remaining four do not produce equipment that meet the efficiency level at the proposed TSL (TSL 3). DOE notes, however, that three of these four manufacturers offer condensing commercial packaged boilers. DOE believes the condensing heat exchanger designs for commercial packaged boilers could be adapted for use in hot water supply boilers. Five of the small businesses primarily manufacture commercial gas-fired storage and electric storage water heaters. Three of these five companies produce primarily high-efficiency condensing gas-fired equipment, while two of the five primarily produce baseline equipment. However, both of the latter companies offer at least one condensing model. Of the remaining small businesses, one exclusively manufacturers condensing gas-fired tankless water heaters, and one rebrands equipment that is produced by other CWH equipment manufacturers.

2. Description and Estimate of Compliance Requirements

As previously mentioned, in addition to direct interviews of small manufacturers, DOE also used feedback from other manufacturer interviews to help evaluate the potential impacts of potential amended standards on small businesses. In addition, DOE used product listings data to better understand the percentage of models small manufacturers may have to convert in order to comply with standards.

In interviews, small manufacturers stated that they may be disproportionately affected by product conversion costs. Product redesign, testing, and certification costs tend to be fixed and do not scale with sales volume. When confronted with new or amended energy conservation standards, small businesses must make investments in research and development to redesign their equipment, but because they often have lower sales volumes, they may need to spread these costs across fewer units. Small manufacturers also stated that they have limited lab space, personnel, and equipment to test their CWH equipment. They argued that they would experience higher testing costs relative to larger manufacturers, as they would need to outsource some or all of their testing at a higher per-unit cost. Small manufacturers pointed out that in general, because they have fewer engineers and product development resources, they would likely have to divert engineering resources from customer and new product initiatives for a longer period of time than would their larger competitors.

These product conversion cost and engineering resource considerations are particularly applicable to the two small manufacturers that primarily offer baseline commercial gas-fired storage water heaters and the four manufacturers that only offer lower-efficiency hot water supply boilers. DOE estimates that approximately 57 percent of commercial gas-fired storage models produced by small CWH equipment manufacturers do not meet the thermal efficiency level proposed in TSL 3. For the two manufacturers that primarily offer baseline commercial gas-fired storage water heaters, DOE estimates that 88 percent of their models do not meet the proposed efficiency levels at TSL 3. For reference, DOE estimates that large commercial gas-fired storage water heater manufacturers would have to convert approximately 76 percent of their commercial gas-fired storage water heater models at TSL 3. For hot water supply boilers, DOE estimates that small and large manufacturers would need to redesign similar proportions of their product offerings. Approximately 86 percent of the models currently

[127] The AHRI Directory is available at: *www.ahridirectory.org/ahriDirectory/pages/home.aspx*.

[128] The CEC database is available at: *http://www.energy.ca.gov/appliances/*.

[129] DOE's Compliance Certification Database is available at *http://www.regulations.doe.gov/certification-data/*.

[130] Hoovers Inc., Company Profiles, Various Companies (Available at: *www.hoovers.com/*).

produced by small CWH equipment manufacturers do not meet the level in TSL 3, while 79 percent of hot water supply boilers produced by large manufacturers do not meet the level in TSL 3.

Smaller manufacturers also stated that they lack the purchasing power of larger manufacturers. The purchasing power issue may be of particular concern to the four manufacturers that produce lower-efficiency hot water supply boilers, because many manufacturers would purchase heat exchangers to comply with the thermal efficiency level proposed in TSL 3. Few hot water supply boiler manufacturers produce condensing boiler heat exchangers domestically, and most condensing boiler heat exchangers are sourced from European companies. A condensing standard, as proposed in TSL 3, could require small manufacturers to purchase a greater proportion of their components. This could exacerbate any pricing disadvantages small businesses experience due to lower purchasing volumes.

Issue 35: DOE seeks comment on the number of small manufacturers, on the potential impacts of amended energy conservation standards on those small manufacturers, and on the severity of those impacts.

3. 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 rule being proposed in this document.

4. Significant Alternatives to the Rule

The discussion in section V.B.2.d analyzes impacts on small businesses that would result from DOE's proposed rule. In addition to the other TSLs being considered, the NOPR TSD includes a regulatory impact analysis (RIA) which addresses the following policy alternatives: (1) No change in standard; (2) consumer rebates; (3) consumer tax credits; (4) voluntary energy efficiency programs; and (5) early replacement.[131] While these alternatives may mitigate to some varying extent the economic impacts on small entities compared to the proposed standards, DOE does not intend to consider these alternatives further because in several cases, they would not be feasible to implement without authority and funding from Congress, and in all cases, DOE has determined that the energy savings of these regulatory alternatives are from 70 to 80 percent smaller than those that would be expected to result from adoption of the proposed standard levels. Accordingly, DOE is declining to adopt any of these alternatives and is proposing the standards set forth in this document. (See chapter 17 of the NOPR TSD for further detail on the policy alternatives DOE considered.)

Additional compliance flexibilities may be available through other means. For example, individual manufacturers may petition for a waiver of the applicable test procedure. (See 10 CFR 431.401.) Further, EPCA provides that a manufacturer whose annual gross revenue from all of its operations does not exceed $8,000,000 may apply for an exemption from all or part of an energy conservation standard for a period not longer than 24 months after the effective date of a final rule establishing the standard. Additionally, Section 504 of the Department of Energy Organization Act, 42 U.S.C. 7194, provides authority for the Secretary to adjust a rule issued under EPCA in order to prevent ''special hardship, inequity, or unfair distribution of burdens'' that may be imposed on that manufacturer as a result of such rule. Manufacturers should refer to 10 CFR part 430, subpart E, and part 1003 for additional details.

C. Review Under the Paperwork Reduction Act of 1995

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. 76 FR 12422 (March 7, 2011); 80 FR 5099 (Jan. 30, 2015). The collection-of-information requirement for the certification and recordkeeping is subject to review and approval by OMB under the Paperwork Reduction Act (PRA). This requirement has been approved by OMB under OMB Control Number 1910–1400. Public reporting burden for the certification is estimated to average 30 hours per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information.

Notwithstanding any other provision of the law, no person is required to respond to, nor shall any person be subject to a penalty for failure to comply with, a collection of information subject to the requirements of the PRA, unless that collection of information displays a currently valid OMB Control Number.

D. Review Under the National Environmental Policy Act of 1969

Pursuant to the National Environmental Policy Act (NEPA) of 1969, DOE has determined that the proposed rule fits within the category of actions included in Categorical Exclusion (CX) B5.1 and otherwise meets the requirements for application of a CX. See 10 CFR part 1021, App. B, B5.1(b); 1021.410(b) and App. B, B(1)–(5). The proposed rule fits within this category of actions because it is a rulemaking that establishes energy conservation standards for consumer products or industrial equipment, and for which none of the exceptions identified in CX B5.1(b) apply. Therefore, DOE has made a CX determination for this rulemaking, and DOE does not need to prepare an Environmental Assessment or Environmental Impact Statement for this proposed rule. DOE's CX determination for this proposed rule is available at *http://energy.gov/nepa/categorical-exclusion-cx-determinations-cx/.*

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 proposed rule and has tentatively determined that it would not have a substantial direct effect on the States, on the relationship between the national government and the States, or on the distribution of power and

[131] The early replacement option includes bulk government purchases, manufacturer promotions, utility incentives, and commercial consumer incentives.

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 proposed rule. States can petition DOE for exemption from such preemption to the extent, and based on criteria, set forth in EPCA (42 U.S.C. 6297). Therefore, Executive Order 13132 requires no further action.

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 proposed rule 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 proposed ''significant intergovernmental mandate,'' and requires an agency plan for giving notice and opportunity for timely input to potentially affected small governments before establishing any requirements that might significantly or uniquely affect them. On March 18, 1997, DOE published a statement of policy on its process for intergovernmental consultation under UMRA. 62 FR 12820. DOE's policy statement is also available at *www.energy.gov/gc/office-general-counsel.*

Although this proposed rule, which proposes amended energy conservation standards for CWH equipment, does not contain a Federal intergovernmental mandate, it may require annual expenditures of $100 million or more by the private sector. Specifically, the proposed rule would likely result in a final rule that could require expenditures of $100 million or more, including: (1) Investment in research and development and in capital expenditures by CWH equipment manufacturers in the years between the final rule and the compliance date for the amended standards, and (2) incremental additional expenditures by consumers to purchase higher-efficiency CWH equipment, starting at the compliance date for the applicable standard.

Section 202 of UMRA authorizes a Federal agency to respond to the content requirements of UMRA in any other statement or analysis that accompanies the proposed rule. (2 U.S.C. 1532(c)) The content requirements of section 202(b) of UMRA relevant to a private sector mandate substantially overlap the economic analysis requirements that apply under section 325(o) of EPCA and Executive Order 12866. The **SUPPLEMENTARY INFORMATION** section of the NOPR and the ''Regulatory Impact Analysis'' section of the TSD for this proposed rule respond to those requirements.

Under section 205 of UMRA, the Department is obligated to identify and consider a reasonable number of regulatory alternatives before promulgating a rule for which a written statement under section 202 is required. (2 U.S.C. 1535(a)) DOE is required to select from those alternatives the most cost-effective and least burdensome alternative that achieves the objectives of the proposed rule unless DOE publishes an explanation for doing otherwise, or the selection of such an alternative is inconsistent with law. As required by 42 U.S.C. 6313(a), this proposed rule would establish amended energy conservation standards for CWH equipment that are designed to achieve the maximum improvement in energy efficiency that DOE has determined to be both technologically feasible and economically justified. A full discussion of the alternatives considered by DOE is presented in the ''Regulatory Impact Analysis'' section of the TSD for this proposed rule.

H. Review Under the Treasury and General Government Appropriations Act, 1999

Section 654 of the Treasury and General Government Appropriations Act, 1999 (Pub. L. 105–277) requires Federal agencies to issue a Family Policymaking Assessment for any rule that may affect family well-being. This rule would not have any impact on the autonomy or integrity of the family as an institution. Accordingly, DOE has concluded that it is not necessary to prepare a Family Policymaking Assessment.

I. Review Under Executive Order 12630

Pursuant to Executive Order 12630, ''Governmental Actions and Interference with Constitutionally Protected Property Rights,'' 53 FR 8859 (March 15, 1988), DOE has determined that this proposed rule would not result in any takings that might require compensation under the Fifth Amendment to the U.S. Constitution.

J. Review Under the Treasury and General Government Appropriations Act, 2001

Section 515 of the Treasury and General Government Appropriations Act, 2001 (44 U.S.C. 3516 note) provides for Federal agencies to review most disseminations of information to the public under information quality guidelines established by each agency pursuant to general guidelines issued by OMB. OMB's guidelines were published at 67 FR 8452 (Feb. 22, 2002), and DOE's guidelines were published at 67 FR 62446 (Oct. 7, 2002). 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

Executive Order 13211, ''Actions Concerning Regulations That

Significantly Affect Energy Supply, Distribution, or Use,'' 66 FR 28355 (May 22, 2001), requires Federal agencies to prepare and submit to OIRA at OMB, a Statement of Energy Effects for any proposed significant energy action. A ''significant energy action'' is defined as any action by an agency that promulgates or is expected to lead to promulgation of a final rule, and that: (1) Is a significant regulatory action under Executive Order 12866, or any successor order; and (2) is likely to have a significant adverse effect on the supply, distribution, or use of energy, or (3) is designated by the Administrator of OIRA as a significant energy action. For any proposed significant energy action, the agency must give a detailed statement of any adverse effects on energy supply, distribution, or use should the proposal be implemented, and of reasonable alternatives to the action and their expected benefits on energy supply, distribution, and use.

DOE has tentatively concluded that the regulatory action in this document, which sets forth proposed 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. Review Under the Information Quality Bulletin for Peer Review

On December 16, 2004, OMB, in consultation with the Office of Science and Technology Policy (OSTP), issued its Final Information Quality Bulletin for Peer Review (the Bulletin). 70 FR 2664 (Jan. 14, 2005). The Bulletin establishes that certain scientific information shall be peer reviewed by qualified specialists before it is disseminated by the Federal Government, including influential scientific information related to agency regulatory actions. The purpose of the bulletin is to enhance the quality and credibility of the Government's scientific information. Under the Bulletin, the energy conservation standards rulemaking analyses are ''influential scientific information,'' which the Bulletin defines as ''scientific information the agency reasonably can determine will have or does have a clear and substantial impact on important public policies or private sector decisions.'' *Id.* at 2667.

In response to OMB's Bulletin, DOE conducted formal in-progress peer reviews of the energy conservation standards development process and analyses and has prepared a Peer Review Report pertaining to the energy conservation standards rulemaking analyses. 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. The ''Energy Conservation Standards Rulemaking Peer Review Report,'' dated February 2007, has been disseminated and is available at the following Web site: *www1.eere.energy.gov/buildings/appliance_standards/peer_review.html*.

VII. Public Participation

A. Attendance at the Public Meeting

The time, date, and location of the public meeting are listed in the **DATES** and **ADDRESSES** sections at the beginning of this document. If you plan to attend the public meeting, please notify Ms. Brenda Edwards at (202) 586–2945 or *Brenda.Edwards@ee.doe.gov*. As explained in the **ADDRESSES** section, foreign nationals visiting DOE Headquarters are subject to advance security screening procedures which require advance notice prior to attendance at the public meeting. If a foreign national wishes to participate in the public meeting, please inform DOE of this fact as soon as possible by contacting Ms. Regina Washington at (202) 586–1214 or by email: *Regina.Washington@ee.doe.gov* so that the necessary procedures can be completed.

DOE requires visitors to have laptops and other devices, such as tablets, checked upon entry into the building. Any person wishing to bring these devices into the Forrestal Building will be required to obtain a property pass. Visitors should avoid bringing these devices, or allow an extra 45 minutes to check in. Please report to the visitor's desk to have devices checked before proceeding through security.

Due to the REAL ID Act implemented by the Department of Homeland Security (DHS), there have been recent changes regarding ID requirements for individuals wishing to enter Federal buildings from specific States and U.S. territories. Driver's licenses from the following States or territory will not be accepted for building entry, and one of the alternate forms of ID listed below will be required. DHS has determined that regular driver's licenses (and ID cards) from the following jurisdictions are not acceptable for entry into DOE facilities: Alaska, American Samoa, Arizona, Louisiana, Maine, Massachusetts, Minnesota, New York, Oklahoma, and Washington. Acceptable alternate forms of Photo-ID include: U.S. Passport or Passport Card; an Enhanced Driver's License or Enhanced ID-Card issued by the States of Minnesota, New York, or Washington (Enhanced licenses issued by these States are clearly marked Enhanced or Enhanced Driver's License); a military ID or other Federal government issued Photo-ID card.

In addition, you can attend the public meeting via webinar. Webinar registration information, participant instructions, and information about the capabilities available to webinar participants will be published on DOE's Web site at: *https://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 Requests To Speak and Prepared General Statements for Distribution

Any person who has an interest in the topics addressed in this document, 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 public meeting. Such persons may hand-deliver requests to speak to the address shown in the **ADDRESSES** section at the beginning of this document between 9:00 a.m. and 4:00 p.m., Monday through Friday, except Federal holidays. Requests may also be sent by mail or email to: Ms. Brenda Edwards, U.S. Department of Energy, Building Technologies Office, Mailstop EE–5B, 1000 Independence Avenue SW., Washington, DC 20585–0121, or *Brenda.Edwards@ee.doe.gov*. Persons who wish to speak should include with their request a computer diskette or CD–ROM 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.

DOE requests persons scheduled to make an oral presentation to submit an advance copy of their statements at least one week before the public meeting. 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 Program. As necessary, requests to give an oral presentation should ask for such alternative arrangements.

C. Conduct of the Public Meeting

DOE will designate a DOE official to preside at the 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 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 public meeting, interested parties may submit further comments on the proceedings, as well as on any aspect of the rulemaking, until the end of the comment period.

The public meeting will be conducted in an informal, conference style. DOE will present summaries of comments received before the 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 allow, 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 and comment on statements made by others. 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 public meeting will accept additional comments or questions from those attending, as time permits. The presiding official will announce any further procedural rules or modification of the above procedures that may be needed for the proper conduct of the public meeting.

A transcript of the public meeting will be included in the docket, which can be viewed as described in the *Docket* section at the beginning of this document and will be accessible on the DOE Web site. In addition, any person may buy a copy of the transcript from the transcribing reporter.

D. Submission of Comments

DOE will accept comments, data, and information regarding this proposed rule before or after the public meeting, but no later than the date provided in the **DATES** section at the beginning of this proposed rule. Interested parties may submit comments, data, and other information using any of the methods described in the **ADDRESSES** section at the beginning of this document.

Submitting comments via www.regulations.gov. The *www.regulations.gov* 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 Web site will waive any CBI claims for the information submitted. For information on submitting CBI, see the Confidential Business Information section below.

DOE processes submissions made through *www.regulations.gov* before posting. Normally, comments will be posted within a few days of being submitted. However, if large volumes of comments are being processed simultaneously, your comment may not be viewable for up to several weeks. Please keep the comment tracking number that *www.regulations.gov* provides after you have successfully uploaded your comment.

Submitting comments via email, hand delivery/courier, or mail. Comments and documents submitted via email, hand delivery, or mail also will be posted to *www.regulations.gov*. If you do not want your personal contact information to be publicly viewable, do not include it in your comment or any accompanying documents. Instead, provide your contact information in a cover letter. Include your first and last names, email address, telephone number, and optional mailing address. The cover letter will not be publicly viewable as long as it does not include any comments.

Include contact information each time you submit comments, data, documents, and other information to DOE. If you submit via mail or hand delivery/courier, please provide all items on a CD, if feasible, in which case it is not necessary to submit printed copies. No telefacsimiles (faxes) will be accepted.

Comments, data, and other information submitted to DOE electronically should be provided in PDF (preferred), Microsoft Word or Excel, WordPerfect, or text (ASCII) file format. Provide documents that are not secured, that are written in English, and that are free of any defects or viruses. Documents should not contain special characters or any form of encryption and, if possible, they should carry the electronic signature of the author.

Campaign form letters. Please submit campaign form letters by the originating organization in batches of between 50 to 500 form letters per PDF or as one form letter with a list of supporters' names compiled into one or more PDFs. This reduces comment processing and posting time.

Confidential Business Information. Pursuant to 10 CFR 1004.11, any person submitting information that he or she believes to be confidential and exempt by law from public disclosure should submit via email, 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. Submit these documents via email or on a CD, if feasible. DOE will make its own determination about the confidential status of the information and treat it according to its determination.

Factors of interest to DOE when evaluating requests to treat submitted information as confidential include: (1)

A description of the items; (2) whether and why such items are customarily treated as confidential within the industry; (3) whether the information is generally known by or available from other sources; (4) whether the information has previously been made available to others without obligation concerning its confidentiality; (5) an explanation of the competitive injury to the submitting person which would result from public disclosure; (6) when such information might lose its confidential character due to the passage of time; and (7) why disclosure of the information would be contrary to the public interest.

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 seeks comment on its tentative conclusions regarding the potential energy savings from analyzing amended standards for standby loss of commercial oil-fired storage water heaters and for thermal efficiency of commercial oil-fired instantaneous water heaters.

Issue 2: The agency assumes no growth in equipment efficiency in absence of new standards; however, DOE requests comment on expected changes over the analysis period in market share by energy efficiency level or average shipment-weighted efficiency for the analyzed CWH equipment classes in the no-new-standards case.

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

Issue 4: DOE requests comment on its proposed changes to its certification, compliance, and enforcement regulations requiring the rated volume to be equal to the mean of the measured volumes in a sample.

Issue 5: DOE requests comment on its proposed modification of the maximum standby loss equations for electric storage and instantaneous water heaters to depend on rated volume instead of measured volume.

Issue 6: DOE requests comment on whether there are significant differences between storage water heaters and storage-type instantaneous water heaters that would justify analyzing these classes separately for amended energy conservations standards.

Issue 7: DOE requests comment on 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. Additionally, DOE requests feedback on what criteria should be used to distinguish between tankless water heaters and hot water supply boilers if separate equipment classes are established.

Issue 8: DOE seeks comment on its proposed equipment class structure, and whether any equipment classes are unnecessary or additional equipment classes are needed.

Issue 9: DOE seeks comment on its tentative conclusion that none of the identified technology options are proprietary, and if any technologies are proprietary, requests additional information regarding proprietary designs and patented technologies.

Issue 10: DOE seeks comment on the representative CWH equipment used in the engineering analysis.

Issue 11: DOE seeks comment on all efficiency levels analyzed for CWH equipment, including thermal efficiency and standby loss levels. In particular, DOE is interested in the feasibility of the max-tech thermal efficiency levels and standby loss levels, including whether these efficiency levels can be achieved using the technologies screened-in during the screening analysis (see section IV.B), and whether higher efficiencies are achievable using technologies that were screened-in during the screening analysis. DOE is also interested in the feasibility of achieving the analyzed standby loss levels using the identified technology options.

Issue 12: DOE seeks input on the reduction in standby loss of gas-fired storage water heaters from the technology options for which DOE estimated standby loss levels (*i.e.,* varying insulation type and thickness, electromechanical flue dampers, and mechanical draft) and the technology options for which DOE did not have sufficient data to develop an estimate (including baffling).

Issue 13: DOE seeks comment on its methodology for manufacturer production cost, manufacturer selling price, and shipping cost estimates for each equipment class and efficiency level.

Issue 14: DOE seeks comment on its proposed method for modifying the maximum standby loss equations for commercial gas-fired storage water heaters and residential-duty storage water heaters.

Issue 15: DOE seeks comment on its approach to convert the thermal efficiency and standby loss levels analyzed for residential-duty commercial water heaters to UEF.

Issue 16: DOE seeks comment on the percentages of shipments allocated to the distribution channels relevant to each equipment class.

Issue 17: DOE requests comment on the estimated market and sector weights for shipments by equipment class.

Issue 18: DOE requests comment on the development of markups at each point in the distribution chain and the overall markup by equipment class.

Issue 19: DOE seeks comment on the assumptions used in determining the venting costs for the relevant types of CWH equipment.

Issue 20: DOE seeks comment on the percentage of installations using polypropylene venting materials in this industry and any limitations such venting has as to maximum available diameters or other limitations.

Issue 21: DOE seeks comment on the installation labor and labor to remove equipment and venting in this analysis.

Issue 22: DOE seeks comment on the overall installed costs by TSL for each equipment class as shown in the Average LCC and PBP Results tables found in section V.B.1.a, Table V.4 through Table V.14.

Issue 23: DOE seeks comment on maintenance labor estimates used in the LCC analysis and the assumption that maintenance costs remain constant as efficiency increases.

Issue 24: DOE seeks comment on the findings of the repair costs of CWH equipment, labor estimates for repairs, and the estimated rate of component repair.

Issue 25: DOE seeks input on actual historical shipments for the three equipment classes for which no historical shipments data exist—residential-duty gas-fired storage water heaters, gas-fired tankless water heaters, and gas-fired hot water supply boilers.

Issue 26: DOE seeks input on the methodology used to estimate the historical shipments for the residential-duty gas-fired storage water heater, gas-fired tankless water heater, and hot water supply boiler equipment classes, particularly in the absence of actual historic shipments data.

Issue 27: DOE seeks input on commercial consumer switching between equipment types or fuel types, and specific information that DOE can use to model such commercial consumer switching. For example, if a commercial consumer switches away from commercial gas-fired storage water heaters, to what type of equipment is the commercial consumer most likely to switch, and is it a one-for-one switch or some other ratio?

Issue 28: DOE seeks input on the shares of shipments allocated to commercial and to residential consumer types.

Issue 29: DOE seeks input on whether the shipment model should assume that multifamily buildings are the only residential building stock in which CWH equipment is used, or whether DOE should continue to use total residential building stocks.

Issue 30: DOE seeks input on the possibility that rebound effect would be significant, and if so, estimates of the impact of the rebound effect on NES.

Issue 31: DOE requests comment on whether manufacturers would incur any product conversion costs (*i.e.,* substantial redesign work or research and development) related to the standby loss levels analyzed in this NOPR.

Issue 32: DOE seeks comment on its assessment of amended standards' potential impacts on direct employment.

Issue 33: DOE seeks comment on its assessment of amended standards' potential impacts on manufacturing capacity.

Issue 34: DOE requests comment on whether the classification of unacceptable blowing agents in the EPA's SNAP final rule will affect the insulating properties of foam insulation used in CWH equipment analyzed in this NOPR. Specifically, DOE seeks data that show the difference in thermal resistivity (*i.e.,* R-value per inch) between insulation currently used in storage water heaters and insulation that would be compliant with the regulations amended in the SNAP final rule, if currently used blowing agents are classified as unacceptable.

Issue 35: DOE seeks comment on the number of small manufacturers, on the potential impacts of amended energy conservation standards on those small manufacturers, and on the severity of those impacts.

VIII. Approval of the Office of the Secretary

The Secretary of Energy has approved publication of this notice of proposed rulemaking.

List of Subjects

10 CFR Part 429

Confidential business information, Energy conservation, Imports, Measurement standards, Reporting and recordkeeping requirements.

10 CFR Part 431

Administrative practice and procedure, Confidential business information, Test procedures, Reporting and recordkeeping requirements.

Issued In Washington, DC, on April 19, 2016.

David Friedman,

Principal Deputy Assistant Secretary, Energy Efficiency and Renewable Energy.

For the reasons set forth in the preamble, DOE proposes to amend parts 429 and 431 of chapter II, subchapter D of title 10, Code of Federal Regulations, as set forth below:

PART 429—CERTIFICATION, COMPLIANCE, AND ENFORCEMENT FOR CONSUMER PRODUCTS AND COMMERCIAL AND INDUSTRIAL EQUIPMENT

■ 1. The authority citation for part 429 continues to read as follows:

Authority: 42 U.S.C. 6291–6317.

■ 2. Section 429.44 is amended by:
■ a. Adding paragraph (b)(1)(ii)(C) [paragraph (b) proposed at 81 FR 28588 (May 9, 2016)];
■ b. Revising paragraph (c)(2);
■ c. Redesignating existing paragraphs (c)(3) and (4) as (c)(4) and (5); and
■ d. Adding new paragraph (c)(3).

The additions and revisions read as follows:

§ 429.44 Commercial water heating equipment.

* * * * *

(b) * * *

(1) * * *

(ii) * * *

(C) Any represented value of the rated storage volume must be equal to the mean of the measured storage volumes of all the units within the sample.

* * * * *

(c) * * *

(2) Pursuant to § 429.12(b)(13), a certification report for equipment manufactured before (*date 3 years after publication in the* ***Federal Register*** *of the final rule establishing amended energy conservation standards for commercial water-heating equipment*) must include the following public equipment-specific information:

(i) Commercial electric storage water heaters: The standby loss in percent per hour (%/h) and the measured storage volume in gallons (gal).

(ii) Commercial gas-fired and oil-fired storage water heaters: The thermal efficiency in percent (%), the standby loss in British thermal units per hour (Btu/h), the rated storage volume in gallons (gal), and the fuel input rate in Btu/h rounded to the nearest 1,000 Btu/h.

(iii) Commercial water heaters and hot water supply boilers with storage capacity greater than 140 gallons: The thermal efficiency in percent (%); whether the storage volume is greater than 140 gallons (Yes/No); whether the tank surface area is insulated with at least R–12.5 (Yes/No); whether a standing pilot light is used (Yes/No); for gas or oil-fired water heaters, whether the basic model has a flue damper or fan assisted combustion (Yes/No); and, if applicable, pursuant to 10 CFR 431.110 of this chapter, the standby loss in British thermal units per hour (Btu/h) and measured storage volume in gallons (gal).

(iv) Commercial gas-fired and oil-fired instantaneous water heaters with storage capacity greater than or equal to 10 gallons and gas-fired and oil-fired hot water supply boilers with storage capacity greater than or equal to 10 gallons: The thermal efficiency in percent (%); the standby loss in British thermal units per hour (Btu/h); the rated storage volume in gallons (gal); the fuel input rate in Btu/h rounded to the nearest 1,000 Btu/h; whether a submerged heat exchanger is used (Yes/No); and whether flow through the water heater is required to initiate burner ignition (Yes/No).

(v) Commercial gas-fired and oil-fired instantaneous water heaters with storage capacity less than 10 gallons and gas-fired and oil-fired hot water supply boilers with storage capacity less than 10 gallons: The thermal efficiency in percent (%), the rated storage volume in gallons (gal), and the fuel input rate in British thermal units per hour (Btu/h) rounded to the nearest 1,000 Btu/h.

(vi) Commercial electric instantaneous water heaters with storage capacity greater than or equal to 10 gallons: The thermal efficiency in percent (%), the standby loss in percent per hour (%/h), and the measured storage volume in gallons (gal).

(vii) Commercial electric instantaneous water heaters with storage capacity less than 10 gallons: The thermal efficiency in percent (%) and the measured storage volume in gallons (gal).

(viii) Commercial unfired hot water storage tanks: The thermal insulation (*i.e.,* R-value) and stored volume in gallons (gal).

(3) Pursuant to § 429.12(b)(13), a certification report for equipment manufactured on or after (*date 3 years after publication in the* ***Federal Register*** *of the final rule establishing*

amended energy conservation standards for commercial water-heating equipment) must include the following public equipment-specific information:

(i) Commercial electric storage water heaters: The standby loss in percent per hour (%/h) and the rated storage volume in gallons (gal).

(ii) Commercial gas-fired and oil-fired storage water heaters: The thermal efficiency in percent (%), the standby loss in British thermal units per hour (Btu/h), the rated storage volume in gallons (gal), and the fuel input rate in British thermal units per hour (Btu/h) rounded to the nearest 1,000 Btu/h.

(iii) Commercial water heaters and hot water supply boilers with storage capacity greater than 140 gallons: The thermal efficiency in percent (%), whether the storage volume is greater than 140 gallons (Yes/No); whether the tank surface area is insulated with at least R–12.5 (Yes/No); whether a standing pilot light is used (Yes/No); for gas or oil-fired water heaters, whether the basic model has a flue damper or fan assisted combustion (Yes/No); and, if applicable, pursuant to 10 CFR 431.110 of this chapter, the standby loss in British thermal units per hour (Btu/h) and rated storage volume in gallons (gal).

(iv) Commercial gas-fired and oil-fired instantaneous water heaters with storage capacity greater than or equal to 10 gallons and gas-fired and oil-fired hot water supply boilers with storage capacity greater than or equal to 10 gallons: The thermal efficiency in percent (%), the standby loss in British thermal units per hour (Btu/h), the rated storage volume in gallons (gal), and the fuel input rate in Btu/h rounded to the nearest 1,000 Btu/h; whether a submerged heat exchanger is used (Yes/No); and whether flow through the water heater is required to initiate burner ignition (Yes/No).

(v) Commercial gas-fired and oil-fired instantaneous water heaters with storage capacity less than 10 gallons and gas-fired and oil-fired hot water supply boilers with storage capacity less than 10 gallons: The thermal efficiency in percent (%), the rated storage volume in gallons (gal), and the fuel input rate in British thermal units per hour (Btu/h) rounded to the nearest 1,000 Btu/h.

(vi) Commercial electric instantaneous water heaters with storage capacity greater than or equal to 10 gallons: The thermal efficiency in percent (%), the standby loss in percent per hour (%/h), and the rated storage volume in gallons (gal).

(vii) Commercial electric instantaneous water heaters with storage capacity less than 10 gallons: The thermal efficiency in percent (%) and the rated storage volume in gallons (gal).

(viii) Commercial unfired hot water storage tanks: The thermal insulation (*i.e.,* R-value) and rated storage volume in gallons (gal).

* * * * *

■ 3. Section 429.134 is amended by revising paragraph (m)(2) [proposed at 81 FR 28588 (May 9, 2016)] to read as follows:

§ 429.134 Product-specific enforcement provisions.

* * * * *

(m) * * *

(2) Verification of rated storage volume. The following provisions apply to commercial water heating equipment manufactured on or after (*date 3 years after publication in the* ***Federal Register*** *of the final rule establishing amended energy conservation standards for commercial water-heating equipment*). The storage volume of the basic model will be measured pursuant to the test requirements of 10 CFR part 431 for each unit tested. The mean of the measured values will be compared to the rated storage volume as certified by the manufacturer. The rated value will be considered valid only if the measurement is within five percent of the certified rating.

(i) If the rated storage volume is found to be within 5 percent of the mean of the measured value of storage volume, then that value will be used as the basis for calculation of the maximum standby loss for the basic model.

(ii) If the rated storage volume is found to vary more than 5 percent from the mean of the measured values, then the mean of the measured values will be used as the basis for calculation of the maximum standby loss for the basic model.

PART 431—ENERGY EFFICIENCY PROGRAM FOR CERTAIN COMMERCIAL AND INDUSTRIAL EQUIPMENT

■ 4. The authority citation for part 431 continues to read as follows:

Authority: 42 U.S.C. 6291–6317.

■ 5. Section 431.110 is revised to read as follows:

§ 431.110 Energy conservation standards and their effective dates.

(a) Each commercial storage water heater, instantaneous water heater, and hot water supply boiler[1] (except for residential-duty commercial water heaters) must meet the applicable energy conservation standard level(s) as follows:

Equipment	Size	Energy conservation standards[a]: Minimum thermal efficiency (equipment manufactured on and after October 9, 2015) (%)	Energy conservation standards[a]: Maximum standby loss (equipment manufactured on and after October 29, 2003)[b]
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[c]	<10 gal	80	N/A.
	≥10 gal	77	$2.30 + 67/V_m$ (%/h).
Gas-fired instantaneous water heaters and hot water supply boilers.	<10 gal	80	N/A.
	≥10 gal	80	$Q/800 + 110(V_r)^{1/2}$ (Btu/h).

[1] Any packaged boiler that provides service water that meets the definition of "commercial packaged boiler" in subpart E of this part, but does not meet the definition of "hot water supply boiler" in subpart G, must meet the requirements that apply to it under subpart E.

Equipment	Size	Energy conservation standards[a]	
		Minimum thermal efficiency (equipment manufactured on and after October 9, 2015) (%)	Maximum standby loss (equipment manufactured on and after October 29, 2003)[b]
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).

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

(b) Each unfired hot water storage tank manufactured on or after October 29, 2003, must have a minimum thermal insulation of R–12.5.

(c) Each commercial water heater, instantaneous water heater, unfired hot water storage tank and hot water supply boiler[2] (except for residential-duty commercial water heaters) manufactured on or after (*date 3 years after publication in the* **Federal Register** *of the final rule establishing amended energy conservation standards for commercial water-heating equipment*) must meet the applicable energy conservation standard level(s) as follows:

Equipment	Specifications	Energy conservation standards[a]	
		Minimum thermal efficiency	Maximum standby loss[b]
Electric storage water heaters	All	N/A	$0.84 \times [0.30 + 27/V_r]$ (%/h).
Gas-fired storage water heaters	All[c]	95	$0.63 \times [Q/800 + 110(V_r)^{1/2}]$ (Btu/h).
Oil-fired storage water heaters	All[c]	80	$Q/800 + 110(V_r)^{1/2}$ (Btu/h).
Electric instantaneous water heaters	<10 gal[c]	80	N/A.
	≥10 gal	77	$2.30 + 67/V_r$ (%/h).
Gas-fired instantaneous water heaters and hot water supply boilers			
Instantaneous water heaters (other than storage-type) and hot water supply boilers.	<10 gal	94	N/A.
	≥10 gal	94	$Q/800 + 110(V_r)^{1/2}$ (Btu/h).
Storage-type instantaneous water heaters.	≥10 gal	95	$0.63 \times [Q/800 + 110(V_r)^{1/2}]$ (Btu/h).
Oil-fired instantaneous water heaters and hot water supply boilers.	<10 gal	80	N/A.
	≥10 gal	78	$Q/800 + 110(V_r)^{1/2}$ (Btu/h).

[a] V_r is the rated volume in gallons. Q is the fuel input rate in Btu/h.
[b] Water heaters and hot water supply boilers having more than 140 gallons of storage capacity need not meet the standby loss requirement if (1) the tank surface area is thermally insulated to R–12.5 or more; (2) a standing pilot light is not used; and (3) for gas or oil-fired storage water heaters, they have a flue damper or fan assisted combustion.
[c] These standards apply to commercial water heating equipment that does not meet the definition of ''residential-duty commercial water heater.'' See paragraph (c) of this section for energy conservation standards applicable to residential-duty commercial water heaters.

(d) Each residential-duty commercial water heater manufactured prior to (*date 3 years after publication in the* ***Federal Register*** *of the final rule establishing amended energy conservation standards for commercial water-heating equipment*) must meet the applicable energy conservation standard level(s) as follows:

Equipment	Specifications[a]	Draw pattern	Uniform energy factor[b]
Gas-fired Storage	>75 kBtu/hr and	Very Small	$0.3261 - (0.0006 \times V_r)$.
	≤105 kBtu/hr and	Low	$0.5219 - (0.0008 \times V_r)$.
	≤120 gal	Medium	$0.5585 - (0.0006 \times V_r)$.
		High	$0.6044 - (0.0005 \times V_r)$.
Oil-fired Storage	>105 kBtu/hr and	Very Small	$0.3206 - (0.0006 \times V_r)$.
	≤140 kBtu/hr and	Low	$0.5577 - (0.0019 \times V_r)$.
	≤120 gal	Medium	$0.6027 - (0.0019 \times V_r)$.
		High	$0.5446 - (0.0018 \times V_r)$.

[2] Any packaged boiler that provides service water that meets the definition of ''commercial packaged boiler'' in subpart E of this part, but does not meet the definition of ''hot water supply boiler'' in subpart G, must meet the requirements that apply to it under subpart E.

Equipment	Specifications [a]	Draw pattern	Uniform energy factor [b]
Electric Instantaneous	>12 kW and ≤58.6 kW and ≤2 gal.	[Reserved]	[Reserved].

[a] Additionally, to be classified as a residential-duty commercial water heater, a commercial water heater must meet the following conditions: (1) If the water heater requires electricity, it must use a single-phase external power supply; and (2) the water heater must not be designed to heat water to temperatures greater than 180 °F.
[b] V_r is the rated storage volume in gallons.

(e) Each residential-duty commercial water heater manufactured on and after (*date 3 years after publication in the* ***Federal Register*** *of the final rule establishing amended energy conservation standards for commercial water-heating equipment*) must meet the applicable energy conservation standard level(s) as follows:

Equipment	Specifications [a]	Draw pattern	Uniform energy factor [b]
Gas-fired Storage	>75 kBtu/h and	Very Small	0.4618 − (0.0010 × Vr).
	≤105 kBtu/h and	Low	0.6626 − (0.0009 × Vr).
	≤120 gal	Medium	0.6996 − (0.0007 × Vr).
		High	0.7311 − (0.0006 × Vr).
Oil-fired storage	>105 kBtu/h and	Very Small	$0.3206 - (0.0006 \times V_r)$.
	≤140 kBtu/h and	Low	$0.5577 - (0.0019 \times V_r)$.
	≤120 gal	Medium	$0.6027 - (0.0019 \times V_r)$.
		High	$0.5446 - (0.0018 \times V_r)$.
Electric Instantaneous	>12 kW and ≤58.6 kW and ≤2 gal.	[Reserved]	[Reserved].

[a] Additionally, to be classified as a residential-duty commercial water heater, a commercial water heater must meet the following conditions: (1) If the water heater requires electricity, it must use a single-phase external power supply; and (2) the water heater must not be designed to heat water to temperatures greater than 180 °F.
[b] V_r is the rated storage volume in gallons.

[FR Doc. 2016–12178 Filed 5–27–16; 8:45 am]
BILLING CODE 6450–01–P