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Energy Conservation Program: Energy Conservation Standards for Residential Boilers; Final Rule

DEPARTMENT OF ENERGY

10 CFR Part 430

[Docket Number EERE–2012–BT–STD–0047]

RIN 1904–AC88

Energy Conservation Program: Energy Conservation Standards for Residential Boilers

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

ACTION: Final rule.

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 residential boilers. EPCA also requires the U.S. Department of Energy (DOE) to periodically determine whether more-stringent, amended standards would be technologically feasible and economically justified, and would save a significant amount of energy. In this final rule, DOE is adopting more-stringent energy conservation standards for residential boilers. It has determined that the amended energy conservation standards for these products would result in significant conservation of energy, and are technologically feasible and economically justified.

DATES: The effective date of this rule is March 15, 2016. Compliance with the amended standards established for residential boilers in this final rule is required on and after January 15, 2021.

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

A link to the docket Web page can be found at: *http://www.regulations.gov/#!docketDetail;D=EERE-2012-BT-STD-0047.* The *www.regulations.gov* Web page contains simple instructions on how to access all documents, including public comments, in the docket.

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

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SUPPLEMENTARY INFORMATION:

Table of Contents

I. Synopsis of the Final Rule
A. Benefits and Costs to Consumers
B. Impact on Manufacturers
C. National Benefits
D. Standby Mode and Off Mode
II. Introduction
A. Authority
B. Background
1. Current Standards
2. History of Standards Rulemaking for Residential Boilers
III. General Discussion
A. Product Classes and Scope of Coverage
B. Test Procedure
C. Technological Feasibility
1. General
2. Maximum Technologically Feasible Levels
D. Energy Savings
1. Determination of Savings
2. Significance of Savings
E. Economic Justification
1. Specific Criteria
a. Economic Impact on Manufacturers and Consumers
b. Savings in Operating Costs Compared to Increase in Price (LCC and PBP)
c. Energy Savings
d. Lessening of Utility or Performance of Products
e. Impact of Any Lessening of Competition
f. Need for National Energy Conservation
g. Other Factors
2. Rebuttable Presumption
F. General Comments
1. Proposed Standard Levels
2. Simultaneous Changes in Test Procedures and Energy Conservation Standards
3. Safety Issues
4. Other
IV. Methodology and Discussion of Related Comments
A. Market and Technology Assessment
1. Scope of Coverage
2. Product Classes
3. Technology Options
B. Screening Analysis
1. Screened-Out Technologies
2. Remaining Technologies
C. Engineering Analysis
1. Efficiency Levels
a. Baseline Efficiency Level and Product Characteristics
b. Other Energy Efficiency Levels
2. Cost-Assessment Methodology
a. Teardown Analysis
b. Cost Model
c. Manufacturing Production Costs
d. Cost-Efficiency Relationship
e. Manufacturer Markup
f. Manufacturer Interviews
D. Markups Analysis
E. Energy Use Analysis
1. Building Sample
2. Space Heating Energy Use
a. Impact of Return Water Temperature on Efficiency
b. Impact of Automatic Means for Adjusting Water Temperature on Energy Use
c. Impact of Jacket Losses on Energy Use
3. Water Heating Energy Use
a. Idle Loss
4. Electricity Use
a. Standby Mode and Off Mode Losses
b. Air Conditioner Electricity Use
5. Standby Mode and Off Mode
F. Life-Cycle Cost and Payback Period Analysis
1. Product Cost
2. Installation Cost
a. Basic Installation Cost
b. Replacement Installations
c. New Construction Installations
d. Total Installation Cost
3. Annual Energy Consumption
4. Energy Prices
5. Maintenance and Repair Costs
6. Product Lifetime
7. Discount Rates
8. Efficiency Distribution in the No-New-Standards Case
9. Payback Period Analysis
G. Shipments Analysis
H. National Impact Analysis
1. Product Efficiency Trends
2. National Energy Savings
3. Net Present Value Analysis
a. Total Annual Installed Cost
b. Total Annual Operating Cost Savings
c. Net Benefit
I. Consumer Subgroup Analysis
J. Manufacturer Impact Analysis
1. Overview
2. Government Regulatory Impact Model
a. Government Regulatory Impact Model Key Inputs
b. Government Regulatory Impact Model Scenarios
3. Manufacturer Interviews
4. Discussion of MIA Comments
K. Emissions Analysis
L. Monetizing Carbon Dioxide and Other Emissions Impacts
1. Social Cost of Carbon
a. Monetizing Carbon Dioxide Emissions
b. Development of Social Cost of Carbon Values
c. Current Approach and Key Assumptions
2. Social Cost of Other Air Pollutants
M. Utility Impact Analysis
N. Employment Impact Analysis
V. Analytical Results and Conclusions
A. Trial Standard Levels
1. TSLs for AFUE Standards
2. TSLs for Standby Mode and Off Mode Standards
B. Economic Justification and Energy Savings
1. Economic Impacts on Individual Consumers

a. Life-Cycle Cost and Payback Period
b. Consumer Subgroup Analysis
c. Rebuttable Presumption Payback Period
2. Economic Impacts on Manufacturers
a. Industry Cash-Flow Analysis Results
b. Impacts on Direct Employment
c. Impacts on Manufacturing Capacity
d. Impacts on Subgroups of Manufacturers
e. Cumulative Regulatory Burden
3. National Impact Analysis
a. Significance of Energy Savings
b. Net Present Value of Consumer Costs and Benefits
c. Indirect Impacts on Employment
4. Impact on Utility or Performance of Products
5. Impact of Any Lessening of Competition
6. Need of the Nation To Conserve Energy
7. Other Factors
8. Summary of National Economic Impacts
C. Conclusion
1. Benefits and Burdens of Trial Standard Levels Considered for Residential Boilers for AFUE Standards
2. Benefits and Burdens of Trial Standard Levels Considered for Residential Boilers for Standby Mode and Off Mode
3. Annualized Benefits and Costs of the Adopted Standards
VI. Procedural Issues and Regulatory Review
A. Review Under Executive Orders 12866 and 13563
B. Review Under the Regulatory Flexibility Act
1. Description and Estimated Number of Small Entities Regulated
2. Description and Estimate of Compliance Requirements
3. Duplication, Overlap, and Conflict With Other Rules and Regulations
4. Significant Alternatives to the Rule
C. Review Under the Paperwork Reduction Act of 1995
D. Review Under the National Environmental Policy Act of 1969
E. Review Under Executive Order 13132
F. Review Under Executive Order 12988
G. Review Under the Unfunded Mandates Reform Act of 1995
H. Review Under the Treasury and General Government Appropriations Act, 1999
I. Review Under Executive Order 12630
J. Review Under the Treasury and General Government Appropriations Act, 2001
K. Review Under Executive Order 13211
L. Review Under the Information Quality Bulletin for Peer Review
M. Congressional Notification
VII. Approval of the Office of the Secretary

I. Synopsis of the Final Rule

Title III, Part B [1] of the Energy Policy and Conservation Act of 1975 (EPCA or the Act), Public Law 94–163 (42 U.S.C. 6291–6309, as codified), established the Energy Conservation Program for Consumer Products Other Than Automobiles.[2] These products include residential boilers, the subject of this document.

Pursuant to EPCA, any new or amended energy conservation standard must be designed to achieve the maximum improvement in energy efficiency that DOE determines is technologically feasible and economically justified. (42 U.S.C. 6295(o)(2)(A)) Furthermore, the new or amended standard must result in a significant conservation of energy. (42 U.S.C. 6295(o)(3)(B)) EPCA specifically provides that DOE must conduct a second round of energy conservation standards rulemaking for residential boilers. (42 U.S.C. 6295(f)(4)(C)) The statute also provides that not later than 6 years after issuance of any final rule establishing or amending a standard, DOE must publish either a notice of determination that standards for the product do not need to be amended, or a notice of proposed rulemaking including new proposed energy conservation standards (proceeding to a final rule, as appropriate). (42 U.S.C. 6295(m)) DOE initiated this rulemaking as required by 42 U.S.C. 6295(f)(4)(C), but once complete, this rulemaking will also satisfy the 6-year review provision under 42 U.S.C. 6295(m).

Furthermore, EISA 2007 amended EPCA to require that any new or amended energy conservation standard adopted after July 1, 2010, shall address standby mode and off mode energy consumption pursuant to 42 U.S.C. 6295(o). (42 U.S.C. 6295(gg)(3)) If feasible, the statute directs DOE to incorporate standby mode and off mode energy consumption into a single standard with the product's active mode energy use. If a single standard is not feasible, DOE may consider establishing a separate standard to regulate standby mode and off mode energy consumption.

In accordance with these and other statutory provisions discussed in this document, DOE is adopting amended annual fuel utilization efficiency (AFUE) energy conservation standards and adopting new standby mode off mode electrical energy conservation standards for residential boilers. The AFUE standards for residential boilers are expressed as minimum AFUE, as determined by the DOE test method (described in section III.B), and are shown in Table I.1, as are the design requirements. Table I.2 shows the standards for standby mode and off mode. These standards apply to all residential boilers listed in Table I.1 and Table I.2 and manufactured in, or imported into, the United States starting on the date five years after January 15, 2021.

TABLE I.1—AFUE ENERGY CONSERVATION STANDARDS FOR RESIDENTIAL BOILERS

[Compliance starting January 15, 2021]

Product class *	AFUE ** (%)	Design requirement
Gas-fired hot water boiler	84	Constant-burning pilot not permitted. Automatic means for adjusting water temperature required (except for boilers equipped with tankless domestic water heating coils).
Gas-fired steam boiler	82	Constant-burning pilot not permitted.
Oil-fired hot water boiler	86	Automatic means for adjusting temperature required (except for boilers equipped with tankless domestic water heating coils).
Oil-fired steam boiler	85	None.
Electric hot water boiler	None	Automatic means for adjusting temperature required (except for boilers equipped with tankless domestic water heating coils).
Electric steam boiler	None	None.

* Product classes are separated by fuel source—gas, oil, or electricity—and heating medium—steam or hot water. See section IV.A.2 for a discussion of product classes.

** AFUE is an annualized fuel efficiency metric that fully accounts for fossil-fuel energy consumption in active, standby, and off modes. See section III.B for a discussion of the AFUE test method.

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

[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).

TABLE I.2—ENERGY CONSERVATION STANDARDS FOR RESIDENTIAL BOILERS STANDBY MODE AND OFF MODE ELECTRICAL ENERGY CONSUMPTION

Product class	Standard: $P_{W,SB}$ (watts)	Standard: $P_{W,OFF}$ (watts)
Gas-fired hot water boiler	9	9
Gas-fired steam boiler	8	8
Oil-fired hot water boiler	11	11
Oil-fired steam boiler	11	11
Electric hot water boiler	8	8
Electric steam boiler	8	8

A. Benefits and Costs to Consumers

Table I.3 presents DOE's evaluation of the economic impacts of the adopted AFUE and standby mode and off mode standards on consumers of residential boilers, as measured by the average life-cycle cost (LCC) savings and the simple payback period (PBP).[3] Table I.4 presents the same results for standby mode and off mode. The average LCC savings are positive for all product classes, and the PBP is less than the average boiler lifetime, which is estimated to be 26.6 years for gas-fired hot water boilers and electric hot water boilers, 23.6 years for gas-fired steam boilers and electric steam boilers, 24.7 for oil-fired hot water boilers, and 19.3 years for oil-fired steam boilers.[4] DOE has not conducted an analysis of an AFUE standard level for electric boilers as the efficiency of these products already approaches 100 percent AFUE.

TABLE I.3—IMPACTS OF AMENDED AFUE ENERGY CONSERVATION STANDARDS ON CONSUMERS OF RESIDENTIAL BOILERS

Product class	Average LCC savings (2014$)	Simple payback period (years)
Gas-fired Hot Water Boiler	364	1.2
Gas-fired Steam Boiler	333	2.7
Oil-fired Hot Water Boiler	626	5.8
Oil-fired Steam Boiler	434	6.7
Electric Hot Water Boiler	(*)	(*)
Electric Steam Boiler	(*)	(*)

* N/A (No Standard).

TABLE I.4—IMPACTS OF STANDBY MODE AND OFF MODE ELECTRICAL ENERGY CONSUMPTION ENERGY CONSERVATION STANDARDS ON CONSUMERS OF RESIDENTIAL BOILERS

Product class	Average LCC savings (2014$)	Simple payback period (years)
Gas-fired Hot Water Boiler	15	6.7
Gas-fired Steam Boiler	18	6.4
Oil-fired Hot Water Boiler	20	6.2
Oil-fired Steam Boiler	13	6.1
Electric Hot Water Boiler	8	8.9
Electric Steam Boiler	6	8.8

Estimates of the combined impact of the adopted AFUE and standby mode and off mode standards on consumers are shown in Table I.5.

TABLE I.5—COMBINED IMPACTS OF ADOPTED AFUE AND STANDBY MODE AND OFF MODE ENERGY CONSERVATION STANDARDS ON CONSUMERS OF RESIDENTIAL BOILERS

Product class	Average LCC savings (2014$)	Simple payback period (years)
Gas-Fired Hot Water Boiler	379	2.3
Gas-Fired Steam Boiler	351	4.2
Oil-Fired Hot Water Boiler	646	6.6
Oil-Fired Steam Boiler	447	7.4
Electric Hot Water Boiler	8	8.9
Electric Steam Boiler	6	8.8

[3] The average LCC savings are measured relative to the efficiency distribution in the no-new-standards case, which depicts the market in the compliance year in the absence of standards (see section IV.F.8). The simple PBP, which is designed to compare specific efficiency levels, is measured relative to the baseline model (see section IV.C.1.a and chapter 5 of the final rule TSD).

[4] DOE used a distribution of boiler lifetimes that ranges from 1 to 60 years. See appendix 8F of the final rule TSD for details of the derivation of the average boiler lifetime.

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

B. Impact on Manufacturers

The industry net present value (INPV) is the sum of the discounted cash flows to the industry from the base year through the end of the analysis period (2014 to 2050). Using a real discount rate of 8.0 percent, DOE estimates that the (INPV) for manufacturers of residential boilers in the base case without amended standards is $367.83 million in 2014$.

DOE analyzed the impacts of AFUE energy conservation standards and standby/off mode electrical energy consumption energy conservation standards on manufacturers separately. Under the adopted AFUE standards, DOE expects that the change in INPV will range from −0.71 to 0.44 percent, which is approximately equivalent to a reduction of −$2.63 million to an increase of $1.62 million. DOE estimates industry conversion costs from the amended AFUE standards to total $2.27 million.

Under the adopted standby mode and off mode standards, DOE expects the change in INPV will range from −0.46 to 0.12 percent, which is approximately equivalent to a decrease of $1.71 million to an increase of $0.45 million. DOE estimates industry conversion costs from the standby mode and off mode standards to total $0.21 million.

DOE's analysis of the impacts of the adopted standards on manufacturers is described in section IV.J of this final rule.

C. National Benefits [5]

DOE's analyses indicate that the adopted AFUE energy conservation standards for residential boilers are expected to save a significant amount of energy. Relative to the case without amended standards, the lifetime energy savings for residential boilers purchased in the 30-year period that begins in the first full year of compliance with the amended standards (2021–2050) amount to 0.16 quadrillion Btu (quads).[6] This represents a savings of 0.6 percent relative to the energy use of these products in the case without amended standards (referred to as the ''no-new-standards case'').

The cumulative net present value (NPV) of total consumer costs and savings for the amended residential boilers AFUE standards ranges from $0.35 billion to $1.20 billion at 7-percent and 3-percent discount rates, respectively. This NPV expresses the estimated total value of future operating-cost savings minus the estimated increased product costs for residential boilers purchased in 2021–2050.

In addition, the amended AFUE standards for residential boilers are expected to have significant environmental benefits. DOE estimates that the AFUE standards would result in cumulative emission reductions (over the same period as for energy savings) of 9.33 million metric tons (Mt) [7] of carbon dioxide (CO_2), 2.075 thousand tons of sulfur dioxide (SO_2), 122.3 tons of nitrogen oxides (NO_X), 71.9 thousand tons of methane (CH_4), 0.09 thousand tons of nitrous oxide (N_2O), and 0.45 pounds of mercury (Hg).[8] The cumulative reduction in CO_2 emissions through 2030 amounts to 0.77 Mt, which is equivalent to the emissions resulting from the annual electricity use of more than 70,000 homes.

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 Federal interagency working group (IWG).[9] The derivation of the SCC values is discussed in section IV.L. Using discount rates appropriate for each set of SCC values, DOE estimates that the net present monetary value of the CO_2 emissions reduction (not including CO_2-equivalent emissions of other gases with global warming potential) from residential boiler AFUE standards is between $0.053 billion and $0.802 billion, with a value of $0.263 billion using the central SCC case represented by $40.0/t in 2015. DOE also estimates that the net present monetary value of the NO_X emissions reduction to be $0.109 billion at a 7-percent discount rate, and $0.328 billion at a 3-percent discount rate.[10]

Table I.6 summarizes the national economic benefits and costs expected to result from the adopted AFUE standards for residential boilers.

[5] All monetary values in this document are expressed in 2014 dollars and, where appropriate, are discounted to 2015 unless explicitly stated otherwise. Energy savings in this section refer to full-fuel-cycle savings (see section IV.H for discussion).

[6] A quad is equal to 10^{15} British thermal units (Btu). The quantity refers to full-fuel-cycle (FFC) energy savings. FFC energy savings includes the energy consumed in extracting, processing, and transporting primary fuels (*i.e.,* coal, natural gas, petroleum fuels), and, thus, presents a more complete picture of the impacts of energy efficiency standards. For more information on the FFC metric, see section IV.H.2.

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

[8] DOE calculated emissions reductions relative to the no-new-standards-case, which reflects key assumptions in the *Annual Energy Outlook 2015* (*AEO 2015)* Reference case, which generally represents current legislation and environmental regulations for which implementing regulations were available as of October 31, 2014. DOE notes that the amended AFUE standards are estimated to cause a very slight increase in mercury emissions due to associated increase in boiler electricity use.

[9] *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*).

[10] 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: *http://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 and SO_2 and Hg emissions.

TABLE I.6—SUMMARY OF NATIONAL ECONOMIC BENEFITS AND COSTS OF AMENDED AFUE ENERGY CONSERVATION STANDARDS FOR RESIDENTIAL BOILERS (TSL 3) *

Category	Present value billion 2014$	Discount rate %
Benefits		
Consumer Operating Cost Savings	0.500	7
	1.468	3
CO_2 Reduction Value ($12.2/t case) **	0.053	5
CO_2 Reduction Value ($40.0/t case) **	0.263	3
CO_2 Reduction Value ($62.3/t case) **	0.425	2.5
CO_2 Reduction Value ($117/t case) **	0.802	3
NO_X Reduction Value †	0.109	7
	0.328	3
Total Benefits ††	0.872	7
	2.058	3
Costs		
Consumer Incremental Installed Costs	0.150	7
	0.270	3
Total Net Benefits		
Including Emissions Reduction Value ††	0.722	7
	1.789	3

* This table presents the costs and benefits associated with residential boilers shipped in 2021–2050. These results include benefits to consumers which accrue after 2050 from the products purchased in 2021–2050.

** The CO_2 values represent global monetized values of the SCC, in 2014$, in 2015 under several scenarios of the updated SCC values. The first three cases use the averages of SCC distributions calculated using 5%, 3%, and 2.5% discount rates, respectively. The fourth case represents the 95th percentile of the SCC distribution calculated using a 3% discount rate. The SCC time series incorporate an escalation factor.

† The $/ton values used for NO_X are described in section IV.L.2. 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: *http://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.

†† Total Benefits for both the 3% and 7% cases are derived using the series corresponding to average SCC with 3-percent discount rate ($40.0/t case).

For the adopted standby mode and off mode standards, the lifetime energy savings for residential boilers purchased in the 30-year period that begins in the first full year of compliance with amended standards (2021–2050) amount to 0.0026 quads. This is a savings of 1.2 percent relative to the standby energy use of these products in the no-new-standards case.

The cumulative NPV of total consumer costs and savings for the adopted standby mode and off mode standards for residential boilers ranges from $0.003 billion to $0.014 billion at 7-percent and 3-percent discount rates, respectively. This NPV expresses the estimated total value of future operating-cost savings minus the estimated increased product costs for residential boilers purchased in 2021–2050.

In addition, the standby mode and off mode standards are expected to have significant environmental benefits. The energy savings are expected to result in cumulative emission reductions (over the same period as for energy savings) of 0.154 Mt of CO_2, 0.087 thousand tons of SO_2, 0.278 thousand tons of NO_X, 0.669 thousand tons of CH_4, 0.0018 thousand tons of N_2O, and 0.642 pounds of Hg. The cumulative reduction in CO_2 emissions through 2030 amounts to 0.013 Mt, which is equivalent to the emissions resulting from the annual electricity use of approximately 1,200 homes.

As noted above, the value of the CO_2 reductions is calculated using a range of values per metric ton of CO_2 (otherwise known as the SCC) developed by a Federal interagency IWG. The derivation of the SCC values is discussed in section IV.L. Using discount rates appropriate for each set of SCC values, DOE estimates that the net present monetary value of the CO_2 emissions reduction from standby mode and off mode standards for residential boilers is between $0.001 billion and $0.013 billion, with a value of $0.004 billion using the central SCC case represented by $40.0/t in 2015. DOE also estimates that the net present monetary value of the NO_X emissions reduction to be $0.0002 billion at a 7-percent discount rate, and $0.0007 billion at a 3-percent discount rate.

Table I.7 summarizes the national economic benefits and costs expected to result from the adopted standby mode and off mode standards for residential boilers.

TABLE I.7—SUMMARY OF NATIONAL ECONOMIC BENEFITS AND COSTS OF ADOPTED STANDBY MODE AND OFF MODE ENERGY CONSERVATION STANDARDS FOR RESIDENTIAL BOILERS (TSL 3) *

Category	Present value (billion 2014$)	Discount rate (%)
Benefits		
Consumer Operating Cost Savings	0.007	7
	0.022	3
CO_2 Reduction Value ($12.2/t case) **	0.001	5
CO_2 Reduction Value ($40.0/t case) **	0.004	3
CO_2 Reduction Value ($62.3/t case) **	0.007	2.5
CO_2 Reduction Value ($117/t case) **	0.013	3
NO_X Reduction Value †	0.0002	7
	0.0007	3
Total Benefits ††	0.012	7
	0.027	3
Costs		
Consumer Incremental Installed Costs	0.004	7
	0.008	3
Total Net Benefits		
Including Emissions Reduction Value ††	0.008	7
	0.019	3

* This table presents the costs and benefits associated with residential boilers shipped in 2021–2050. These results include benefits to consumers which accrue after 2050 from the products purchased in 2021–2050.

** The CO_2 values represent global monetized values of the SCC, in 2014$, in 2015 under several scenarios of the updated SCC values. The first three cases use the averages of SCC distributions calculated using 5%, 3%, and 2.5% discount rates, respectively. The fourth case represents the 95th percentile of the SCC distribution calculated using a 3% discount rate. The SCC time series incorporate an escalation factor.

† The $/ton values used for NO_X are described in section IV.L.2. 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: *http://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.

†† Total Benefits for both the 3% and 7% cases are derived using the series corresponding to average SCC with 3-percent discount rate ($40.0/t case).

The benefits and costs of the adopted energy conservation standards, for residential boiler products sold in 2021–2050, can also be expressed in terms of annualized values. Benefits and costs for the AFUE standards are considered separately from benefits and costs for the standby mode and off mode electrical consumption standards, because for the reasons explained in section I.D below, it was not technically feasible to develop a single, integrated standard. The monetary values for the total annualized net benefits are the sum of: (1) The national economic value of the benefits in reduced consumer operating cost, minus (2) the increases in product purchase price and installation costs, plus (3) the value of the benefits of CO_2 and NO_X emission reductions, all annualized.[11]

Although the value of operating cost savings and CO_2 emission reductions are both important, two issues are relevant. First, the national operating cost savings are domestic U.S. consumer monetary savings that occur as a result of market transactions, whereas the value of CO_2 reductions is based on a global value. Second, the assessments of operating cost savings and CO_2 savings are performed with different methods that use different time frames for analysis. The national operating cost savings is measured for the lifetime of residential boilers shipped in 2021–2050. Because CO_2 emissions have a very long residence time in the atmosphere,[12] the SCC values in future years reflect future CO_2-emissions impacts that continue beyond 2100.

Estimates of annualized benefits and costs of the adopted AFUE standards for residential boilers are shown in Table I.8.

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 SCC series that has a value of $40.0/t in 2015),[13] the estimated cost of the AFUE standards in this rule is $17.0 million per year in increased equipment costs, while the estimated annual benefits are $56.5 million in reduced equipment operating costs, $15.5 million in CO_2 reductions, and $12.3 million in reduced NO_X

[11] 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.,* 2021 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.7. 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.

[12] The atmospheric lifetime of CO_2 is estimated of the order of 30–95 years. Jacobson, MZ (2005), ''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.

[13] DOE used a 3-percent discount rate because the SCC values for the series used in the calculation were derived using a 3-percent discount rate (see section IV.L).

emissions. In this case, the net benefit amounts to $67.4 million per year. Using a 3-percent discount rate for all benefits and costs and the SCC series that has a value of $40.0/t in 2015, the estimated cost of the AFUE standards is $15.9 million per year in increased equipment costs, while the estimated annual benefits are $86.8 million in reduced operating costs, $15.5 million in CO_2 reductions, and $19.4 million in reduced NO_X emissions. In this case, the net benefit amounts to $105.8 million per year.

TABLE I.8—ANNUALIZED BENEFITS AND COSTS OF AMENDED AFUE ENERGY CONSERVATION STANDARDS FOR RESIDENTIAL BOILERS (TSL 3) *

	Discount rate %	(Million 2014$/year)		
		Primary estimate *	Low net benefits estimate *	High net benefits estimate *
Benefits				
Consumer Operating Cost Savings	7	56.5	53.5	60.1
	3	86.8	81.6	92.8
CO_2 Reduction Value ($12.2/t case) **	5	4.4	4.3	4.5
CO_2 Reduction Value ($40.0/t case) **	3	15.5	15.3	15.8
CO_2 Reduction Value ($62.3/t case) **	2.5	23.0	22.7	23.4
CO_2 Reduction Value ($117/t case) **	3	47.5	46.8	48.3
NO_X Reduction Value †	7	12.3	12.2	28.0
	3	19.4	19.2	43.2
Total Benefits ††	7 plus CO_2 range	73 to 116	70 to 112	93 to 136
	7	84.4	81.0	104.0
	3 plus CO_2 range	111 to 154	105 to 148	141 to 184
	3	121.7	116.1	151.9
Costs				
Consumer Incremental Installed Costs	7	17.0	19.9	14.7
	3	15.9	19.2	13.4
Net Benefits				
Total ††	7 plus CO_2 range	56 to 99	50 to 93	78 to 122
	7	67.4	61.1	89.3
	3 plus CO_2 range	95 to 138	86 to 128	127 to 171
	3	105.8	96.9	138.5

This table presents the annualized costs and benefits associated with residential boilers shipped in 2021–2050. These results include benefits to consumers which accrue after 2050 from the products purchased in 2021–2050. The Primary, Low Benefits, and High Benefits Estimates utilize projections of energy prices from the *AEO 2015* Reference case, Low Economic Growth case, and High Economic Growth case, respectively. In addition, incremental product costs reflect a medium decline rate in the Primary Estimate, a low decline rate in the Low Benefits Estimate, and a high decline rate in the High Benefits Estimate. The methods used to derive projected price trends are explained in section IV.F.1.

** The CO_2 values represent global monetized values of the SCC, in 2014$, in 2015 under several scenarios of the updated SCC values. The first three cases use the averages of SCC distributions calculated using 5%, 3%, and 2.5% discount rates, respectively. The fourth case represents the 95th percentile of the SCC distribution calculated using a 3% discount rate. The SCC time series incorporate an escalation factor.

† 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: *http://www3.epa.gov/ttnecas1/regdata/RIAs/111dproposalRIAfinal0602.pdf*.) For DOE's Primary Estimate and Low Net Benefits Estimate, 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). For DOE's High Net Benefits Estimate, the benefit-per-ton estimates were based on the Six Cities study (Lepuele et al., 2011), which are nearly two-and-a-half times larger than those from the ACS study. Because of the sensitivity of the benefit-per-ton estimate to the geographical considerations of sources and receptors of emission, 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% and 7% cases are derived using the series corresponding to the average SCC with the 3-percent discount rate ($40.0/t) case. 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.

Estimates of annualized benefits and costs of the adopted standby mode and off mode standards are shown in Table I.9. 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 SCC series that has a value of $40.0/t in 2015), the estimated cost of the residential boiler standby mode and off mode standards in this rule is $0.46 million per year in increased equipment costs, while the estimated annual benefits are $0.84 million in reduced equipment operating costs, $0.25 million in CO_2 reductions, and $0.03 million in reduced NO_X emissions. In this case, the net benefit amounts to $0.66 million per year. Using a 3-percent discount rate for all benefits and costs and the SCC series that has a value of $40.0/t in 2015, the estimated cost of the AFUE standards is $0.46 million per year in increased equipment costs, while the estimated annual benefits are $1.28 million in reduced operating costs, $0.25 million in CO_2 reductions, and $0.04 million in reduced NO_X emissions. In this case, the net benefit amounts to $1.11 million per year.

TABLE I.9—ANNUALIZED BENEFITS AND COSTS OF ADOPTED STANDBY MODE AND OFF MODE ENERGY CONSERVATION STANDARDS FOR RESIDENTIAL BOILERS (TSL 3)*

	Discount rate (%)	(Million 2014$/year)		
		Primary estimate *	Low net benefits estimate *	High net benefits estimate *
Benefits				
Consumer Operating Cost Savings	7	0.84	0.81	0.89
	3	1.28	1.25	1.38
CO_2 Reduction Value ($12.2/t case) **	5	0.07	0.07	0.07
CO_2 Reduction Value ($40.0/t case) **	3	0.25	0.25	0.26
CO_2 Reduction Value ($62.3/t case) **	2.5	0.37	0.36	0.38
CO_2 Reduction Value ($117/t case) **	3	0.77	0.75	0.79
NO_X Reduction Value †	7	0.03	0.03	0.06
	3	0.04	0.04	0.10
Total Benefits ††	7 plus CO_2 range	0.94 to 1.63	0.91 to 1.59	1.02 to 1.74
	7	1.12	1.09	1.21
	3 plus CO_2 range	1.40 to 2.09	1.36 to 2.04	1.54 to 2.26
	3	1.58	1.54	1.73
Costs				
Consumer Incremental Installed Costs	7	0.46	0.45	0.47
	3	0.46	0.45	0.47
Net Benefits				
Total ††	7 plus CO_2 range	0.48 to 1.17	0.46 to 1.14	0.55 to 1.26
	7	0.66	0.63	0.73
	3 plus CO_2 range	0.93 to 1.63	0.91 to 1.59	1.07 to 1.78
	3	1.11	1.09	1.25

* This table presents the annualized costs and benefits associated with residential boilers shipped in 2021–2050. These results include benefits to consumers which accrue after 2050 from the products purchased in 2021–2050. The Primary, Low Benefits, and High Benefits Estimates utilize projections of energy prices from the *AEO 2015* Reference case, Low Economic Growth case, and High Economic Growth case, respectively.

** The CO_2 values represent global monetized values of the SCC, in 2014$, in 2015 under several scenarios of the updated SCC values. The first three cases use the averages of SCC distributions calculated using 5%, 3%, and 2.5% discount rates, respectively. The fourth case represents the 95th percentile of the SCC distribution calculated using a 3% discount rate. The SCC time series incorporate an escalation factor.

† 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: *http://www3.epa.gov/ttnecas1/regdata/RIAs/111dproposalRIAfinal0602.pdf.*) For DOE's Primary Estimate and Low Net Benefits Estimate, 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). For DOE's High Net Benefits Estimate, the benefit-per-ton estimates were based on the Six Cities study (Lepuele et al., 2011), which are nearly two-and-a-half times larger than those from the ACS study. Because of the sensitivity of the benefit-per-ton estimate to the geographical considerations of sources and receptors of emission, 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% and 7% cases are derived using the series corresponding to the average SCC with the 3-percent discount rate ($40.0/t) case. 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.

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

Based on the analyses culminating in this final rule, DOE found the benefits to the Nation of the standards (energy savings, positive NPV of consumer benefits, consumer LCC savings, and emission reductions) for both AFUE as well as standby mode and off would outweigh the burdens (loss of INPV for manufacturers and LCC increases for some consumers). DOE has concluded that the standards in this final rule represent the maximum improvement in energy efficiency that is technologically feasible and economically justified, and would result in significant conservation of energy.

DOE also added the annualized benefits and costs from the individual annualized tables to provide a combined benefit and cost estimate of the adopted AFUE and standby mode and off mode standards, as shown in Table I.10.[14] 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 SCC series that has a value of $40.0/t in 2015), the estimated cost of the residential boiler AFUE and standby mode and off mode standards in this rule is $17.4 million per year in increased equipment costs, while the estimated annual benefits are $57.4 million in reduced equipment operating costs, $15.8 million in CO_2 reductions, and $12.4 million in reduced NO_X emissions. In this case, the net benefit amounts to $68.1 million per year. Using a 3-percent discount rate for all benefits and costs and the SCC series that has a value of $40.0/t in 2015, the estimated cost of the residential boiler AFUE and standby mode and off mode standards in this rule is $16.4 million per year in increased equipment costs, while the estimated annual benefits are $88.1 million in reduced equipment operating costs, $15.8 million in CO_2

[14] To obtain the combined results, DOE added the results for the AFUE standards in Table I.8 with the results for the standby standards in Table I.9.

reductions, and $19.4 million in reduced NO_X emissions. In this case, the net benefit amounts to $106.9 million per year.

TABLE I.10—ANNUALIZED BENEFITS AND COSTS OF ADOPTED AFUE AND STANDBY MODE AND OFF MODE ENERGY CONSERVATION STANDARDS FOR RESIDENTIAL BOILERS (TSL 3) *

	Discount rate	(Million 2014$/year)		
		Primary estimate *	Low net benefits estimate *	High net benefits estimate *
Benefits				
Consumer Operating Cost Savings	7%	57.4	54.3	61.0.
	3%	88.1	82.8	94.2.
CO_2 Reduction Value ($12.2/t case) **	5%	4.5	4.4	4.6.
CO_2 Reduction Value ($40.0/t case) **	3%	15.8	15.6	16.1.
CO_2 Reduction Value ($62.3/t case) **	2.5%	23.4	23.0	23.8.
CO_2 Reduction Value ($117/t case) **	3%	48.2	47.5	49.1.
NO_X Reduction Value †	7%	12.4	12.2	28.0.
	3%	19.4	19.2	43.3.
Total Benefits ††	7% plus CO_2 range.	74.2 to 117.9	70.9 to 114	93.6 to 138.
	7%	85.5	82.1	105.
	3% plus CO_2 range.	112 to 156	106 to 150	142 to 187.
	3%	123.3	117.6	153.6.
Costs				
Consumer Incremental Product Costs	7%	17.4	20.3	15.1.
	3%	16.4	19.6	13.9.
Net Benefits				
Total ††	7% plus CO_2 range.	56.8 to 100	50.6 to 93.7	78.5 to 123.
	7%	68.1	61.8	90.0.
	3% plus CO_2 range.	95.6 to 139	86.8 to 130	128 to 173.
	3%	106.9	98.0	139.7.

* This table presents the annualized costs and benefits associated with residential boilers shipped in 2021–2050. These results include benefits to consumers which accrue after 2050 from the products purchased in 2021–2050. The Primary, Low Benefits, and High Benefits Estimates utilize projections of energy prices from the *AEO 2015* Reference case, Low Economic Growth case, and High Economic Growth case, respectively. In addition, incremental product costs reflect a medium decline rate in the Primary Estimate, a low decline rate in the Low Benefits Estimate, and a high decline rate in the High Benefits Estimate. The methods used to derive projected price trends are explained in section IV.F.1.

** The CO_2 values represent global monetized values of the SCC, in 2014$, in 2015 under several scenarios of the updated SCC values. The first three cases use the averages of SCC distributions calculated using 5%, 3%, and 2.5% discount rates, respectively. The fourth case represents the 95th percentile of the SCC distribution calculated using a 3% discount rate. The SCC time series incorporate an escalation factor.

† 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: *http://www3.epa.gov/ttnecas1/regdata/RIAs/111dproposalRIAfinal0602.pdf.*) For DOE's Primary Estimate and Low Net Benefits Estimate, 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). For DOE's High Net Benefits Estimate, the benefit-per-ton estimates were based on the Six Cities study (Lepuele et al., 2011), which are nearly two-and-a-half times larger than those from the ACS study. Because of the sensitivity of the benefit-per-ton estimate to the geographical considerations of sources and receptors of emission, 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% and 7% cases are derived using the series corresponding to the average SCC with the 3-percent discount rate ($40.0/t) case. 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. Standby Mode and Off Mode

As discussed in section II.A of this final rule, any final rule for amended or new energy conservation standards that is published on or after July 1, 2010 must address standby mode and off mode energy use. (42 U.S.C. 6295(gg)(3)) As a result, DOE has analyzed and is adopting new energy conservation standards for the standby mode and off mode electrical energy consumption of residential boilers.

AFUE, the statutory metric for residential boilers, does not incorporate standby mode or off mode use of electricity, although it already fully addresses use in these modes of fossil fuels by gas-fired and oil-fired boilers. In the October 2010 test procedure final rule for residential furnaces and boilers, DOE determined that incorporating standby mode and off mode electricity consumption into a single standard for residential furnaces and boilers is not technically feasible. 75 FR 64621, 64626–27 (Oct. 20, 2010). DOE concluded that a metric that integrates standby mode and off mode electricity consumption into AFUE is not technically feasible, because the standby mode and off mode energy usage, when measured, is essentially lost in practical terms due to rounding conventions for certifying furnace and boiler compliance with Federal energy conservation standards. *Id.* Therefore, in this final rule, DOE is adopting amended boiler standards that are AFUE levels, which exclude standby mode and off mode electricity use; furthermore, DOE is adopting separate standards that are maximum wattage (W) levels to address the standby mode ($P_{W,SB}$) and off mode ($P_{W,OFF}$) electrical energy use of boilers. DOE also presents corresponding trial standard levels (TSLs) for energy consumption in standby mode and off mode. DOE has decided to use a maximum wattage requirement to regulate standby mode and off mode for boilers. DOE believes using an annualized metric could add unnecessary complexities, such as trying to estimate an assumed number of hours that a boiler typically spends in standby mode. Instead, DOE believes that a maximum wattage standard is the most straightforward metric for regulating standby mode and off mode energy consumption of boilers and will result in the least amount of industry and consumer confusion.

DOE is using the metrics just described—AFUE, $P_{W,SB}$, and $P_{W,OFF}$—in the amended energy conservation standards in this rulemaking for residential boilers. This approach satisfies the mandate of 42 U.S.C. 6295(gg)(3) that amended standards address standby mode and off mode energy use. The various analyses performed by DOE to evaluate minimum standards for standby mode and off mode electrical energy consumption for boilers are discussed further in section IV.E of this final rule.

II. Introduction

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

A. Authority

Title III, Part B of the Energy Policy and Conservation Act of 1975 (EPCA or the Act), Pub. L. 94–163 (codified as 42 U.S.C. 6291–6309) established the Energy Conservation Program for Consumer Products Other Than Automobiles, a program covering most major household appliances (collectively referred to as ''covered products''). These products include the residential boilers that are the subject of this rulemaking. (42 U.S.C. 6292(a)(5)) EPCA, as amended, prescribed energy conservation standards for these products (42 U.S.C. 6295(f)(1) and (3)), and directed DOE to conduct future rulemakings to determine whether to amend these standards (42 U.S.C. 6295(f)(4)). Under 42 U.S.C. 6295(m), the agency must periodically review its already-established energy conservation standards for a covered product no later than 6 years from the issuance of a final rule establishing or amending a standard for a covered product. This rulemaking satisfies both statutory provisions (42 U.S.C. 6295(f)(4) and (m)).

Pursuant to EPCA, DOE's energy conservation program for covered products consists essentially of four parts: (1) Testing; (2) labeling; (3) establishment of Federal energy conservation standards; and (4) certification and enforcement procedures. The Federal Trade Commission (FTC) is primarily responsible for labeling, and DOE implements the remainder of the program. Subject to certain criteria and conditions, DOE is required to develop test procedures to measure the energy efficiency, energy use, or estimated annual operating cost of each covered product. (42 U.S.C. 6295(o)(3)(A) and (r)) Manufacturers of covered products must use the prescribed DOE test procedure as the basis for certifying to DOE that their products comply with the applicable energy conservation standards adopted under EPCA and when making representations to the public regarding the energy use or efficiency of those products. (42 U.S.C. 6293(c) and 6295(s)) Similarly, DOE must use these test procedures to determine whether the products comply with standards adopted pursuant to EPCA. (42 U.S.C. 6295(s)) The DOE test procedure for residential boilers appears at title 10 of the Code of Federal Regulations (CFR) part 430, subpart B, appendix N. In 2012, DOE initiated a rulemaking to review the residential furnaces and boilers test procedure. In March 2015, DOE published a notice of proposed rulemaking (NOPR) outlining the proposed changes to the test procedure. 80 FR 12876 (March 11, 2015). In January 2016, DOE published a final rule outlining the final changes made to the test procedure. (See EERE–2012–BT–TP–0024). Details regarding this rulemaking are discussed in section III.B.

DOE must follow specific statutory criteria for prescribing new or amended standards for covered products, including residential boilers. Any new or amended standard for a covered product must be designed to achieve the maximum improvement in energy efficiency that is technologically feasible and economically justified. (42 U.S.C. 6295(o)(2)(A) and (3)(B)) Furthermore, DOE may not adopt any standard that would not result in the significant conservation of energy. (42 U.S.C. 6295(o)(3)) Moreover, DOE may not prescribe a standard: (1) For certain products, including residential boilers, if no test procedure has been established for the product, or (2) if DOE determines by rule that the standard is not technologically feasible or economically justified. (42 U.S.C. 6295(o)(3)(A)–(B)) In deciding whether a proposed standard is economically justified, after receiving comments on the proposed standard, DOE must determine whether the benefits of the standard exceed its burdens. (42 U.S.C. 6295(o)(2)(B)(i)) DOE must make this determination by, to the greatest extent practicable, considering the following seven statutory factors:

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

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

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

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

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

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

(7) Other factors the Secretary of Energy (Secretary) considers relevant. (42 U.S.C. 6295(o)(2)(B)(i)(I)–(VII))

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

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

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

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

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

B. Background

1. Current Standards

In a final rule published on July 28, 2008 (2008 final rule), DOE prescribed energy conservation standards for residential boilers manufactured on or after September 1, 2012. 73 FR 43611. These standards are set forth in DOE's regulations at 10 CFR 430.32(e)(2)(ii) and are repeated in Table II.1 below.

TABLE II.1—FEDERAL ENERGY EFFICIENCY STANDARDS FOR RESIDENTIAL BOILERS

Product class	Minimum annual fuel utilization efficiency (%)	Design requirements
Gas-fired Hot Water Boiler	82	No Constant-Burning Pilot, Automatic Means for Adjusting Water Temperature.*
Gas-fired Steam Boiler	80	No Constant-Burning Pilot.
Oil-fired Hot Water Boiler	84	Automatic Means for Adjusting Temperature.*
Oil-fired Steam Boiler	82	None.
Electric Hot Water Boiler	None	Automatic Means for Adjusting Temperature.*
Electric Steam Boiler**	None	None.

* Excluding boilers equipped with a tankless domestic water heating coil.

** Although the "Electric steam boiler" product class is not included in the table at 10 CFR 430.32(e)(2)(ii), according to 42 U.S.C. 6295(f), there are no minimum AFUE or design requirements for these products. In order to clarify their status, DOE is including these products in both the AFUE and standby/off standards tables as part of this final rule.

2. History of Standards Rulemaking for Residential Boilers

Given the somewhat complicated interplay of recent DOE rulemakings and statutory provisions related to residential boilers, DOE provides the following regulatory history as background leading to the present rulemaking. On November 19, 2007, DOE published a final rule in the **Federal Register** (November 2007 final rule) revising the energy conservation standards for furnaces and boilers, which addressed the first required review of standards for boilers under 42 U.S.C. 6295(f)(4)(B). 72 FR 65136. Compliance with the standards in the November 2007 final rule would have been required by November 19, 2015. However, on December 19, 2007, EISA 2007, Pub. L. 110–140, was signed into law, which further revised the energy conservation standards for residential boilers. More specifically, EISA 2007 amended EPCA to revise the AFUE requirements for residential boilers and set design requirements for most product classes. (42 U.S.C. 6295(f)(3)) EISA 2007 required compliance with the amended energy conservation standards for residential boilers beginning on September 1, 2012.

Only July 15, 2008, DOE issued a final rule technical amendment to the 2007 final rule, which was published in the **Federal Register** on July 28, 2008, to codify the energy conservation standard levels, the design requirements, and compliance dates for residential boilers outlined in EISA 2007. 73 FR 43611. For gas-fired hot water boilers, oil-fired hot water boilers, and electric hot water boilers, EISA 2007 requires that residential boilers manufactured after September 1, 2012 have an automatic means for adjusting water temperature. (42 U.S.C. 6295(f)(3)(A)–(C); 10 CFR 430.32(e)(2)(ii)–(iv)) The automatic means for adjusting water temperature must ensure that an incremental change in the inferred heat load produces a corresponding incremental change in the temperature of the water supplied by the boiler. EISA 2007 also disallows the use of constant-burning pilot lights in gas-fired hot water boilers and gas-fired steam boilers.

DOE initiated this rulemaking pursuant to 42 U.S.C. 6295(f)(4)(C), which requires DOE to conduct a second round of amended standards rulemaking for residential boilers. EPCA, as amended by EISA 2007, also requires that not later than 6 years after issuance of any final rule establishing or amending a standard, DOE must publish either a notice of the determination that standards for the product do not need to be amended, or a notice of proposed rulemaking including proposed energy conservation standards (proceeding to a final rule, as appropriate). (42 U.S.C. 6295(m)) This rulemaking will satisfy both statutory provisions.

Furthermore, EISA 2007 amended EPCA to require that any new or amended energy conservation standard adopted after July 1, 2010, shall address standby mode and off mode energy consumption pursuant to 42 U.S.C. 6295(o). (42 U.S.C. 6295(gg)(3)) If feasible, the statute directs DOE to incorporate standby mode and off mode energy consumption into a single standard with the product's active mode energy use. If a single standard is not feasible, DOE may consider establishing a separate standard to regulate standby mode and off mode energy consumption. Consequently, DOE considered standby mode and off mode energy use as part of this rulemaking for residential boilers.

DOE initiated this current rulemaking by issuing an analytical Framework Document, ''Rulemaking Framework for Residential Boilers'' (February 11, 2013). DOE published the notice of public meeting and availability of the Framework Document for residential boilers in the **Federal Register** on February 11, 2013. 78 FR 9631. The residential boiler energy conservation standards rulemaking docket is EERE–2012–BT–STD–0047. See: *http://www1.eere.energy.gov/buildings/appliance_standards/rulemaking.aspx?ruleid=112.*

The Framework Document explained the issues, analyses, and process that DOE anticipated using to develop energy conservation standards for residential boilers. DOE held a public meeting on March 13, 2013, to solicit comments from interested parties regarding DOE's analytical approach. The comment period for the Framework Document closed on March 28, 2013.

To further develop the energy conservation standards for residential boilers, DOE gathered additional information and performed an initial technical analysis. This process culminated in publication in the **Federal Register** on February 11, 2014, of the notice of data availability (NODA), which announced the availability of analytical results and modeling tools. 79 FR 8122. In that document, DOE presented its initial analysis of potential amended energy conservation standards for residential boilers, and requested comment on the following matters discussed in the analysis: (1) The product classes and scope of coverage; (2) the analytical framework, models, and tools that DOE is using to evaluate potential standards; and (3) the results of the preliminary analyses performed by DOE. *Id.* DOE also invited written comments on these subjects, as well as any other relevant issues, and announced the availability of supporting documentation on its Web site at: *http://www.regulations.gov/#!documentDetail;D=EERE-2012-BT-STD-0047-0015.*

A PDF copy of the supporting documentation is available at *http://www.regulations.gov/#!documentDetail;D=EERE-2012-BT-STD-0047-0011.* The comment period closed on March 13, 2014.

On March 31, 2015, DOE published a notice of proposed rulemaking in the **Federal Register** (March 2015 NOPR). 80 FR 17222. In the March 2015 NOPR, DOE addressed in detail the comments received in earlier stages of the rulemaking, and proposed amended energy conservation standards for residential boilers. In conjunction with the March 2015 NOPR, DOE also published on its Web site the complete technical support document (TSD) for the proposed rule, which incorporated the analysis DOE conducted and technical documentation for each analysis. Also published on DOE's Web site were the LCC analysis spreadsheet and the national impact analysis standard spreadsheet. These materials are available at: *https://www1.eere.energy.gov/buildings/appliance_standards/product.aspx?productid=89.*

In the March 2015 NOPR, DOE identified twenty four issues on which it was particularly interested in receiving comments and views of interested parties. 80 FR 17222, 17303–17304 (March 31, 2015). The comment period was initially set to end June 1, 2015, but it was subsequently extended to July 1, 2015 in a **Federal Register** notice published on May 20, 2015. 80 FR 28852. After the publication of the March 2015 NOPR, DOE received written comments on these and other issues. DOE also held a public meeting in Washington, DC, on April 30, 2015 to discuss and receive comments regarding the tools and methods DOE used in the NOPR analysis, as well as the results of that analysis. DOE also invited written comments and announced the availability of a NOPR analysis technical support document (NOPR TSD). The NOPR TSD is available at: *http://www.regulations.gov/#!documentDetail;D=EERE-2012-BT-STD-0047-0036.*

The NOPR TSD described in detail DOE's analysis of potential standard levels for residential boilers. The document also described the analytical framework used in considering standard levels, including a description of the methodology, the analytical tools, and the relationships between the various analyses. In addition, the NOPR TSD presented each analysis that DOE performed to evaluate residential boilers, including descriptions of inputs, sources, methodologies, and results. DOE included the same analyses that were conducted at the preliminary analysis stage, with revisions based on comments received and additional research.

Statements received after publication of the Framework Document, at the Framework public meeting, and comments received after the publication of the NODA and NOPR have helped identify issues involved in this rulemaking and have provided information that has contributed to DOE's resolution of these issues. The Department considered these statements and comments in developing revised engineering and other analyses for this final rule.

III. General Discussion

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

DOE received 21 comments in response to the March 2015 NOPR. These commenters include: A joint comment from the American Council for an Energy-Efficient Economy (ACEEE), the Appliance Standards Awareness Project (ASAP), the Alliance to Save Energy (ASE), the Consumer Federation of America (CFA), the National Consumer Law Center (NCLC), the Natural Resources Defense Council (NRDC), and the Northeast Energy Efficiency Partnerships (NEEP); four comments from the Air-Conditioning, Heating, and Refrigeration Institute (AHRI); a comment from the Air Conditioning Contractors of America (ACCA); a comment from the Plumbing-Heating-Cooling Contractors National Association (PHCC); a comment from U.S. Chamber of Commerce; a comment from the Cato Institute; a comment from Oilheat Manufacturers Association; a comment from Exquisite Heat; and an anonymous comment. Manufacturers submitting written comments include: Energy Kinetics, Weil-McLain, Burnham

Holdings (Burnham), and Lochinvar. Gas utilities and associations who submitted written comments include: A joint comment from the American Gas Association (AGA) and the American Public Gas Association (APGA); Philadelphia Gas Works (PGW); National Propane Gas Association (NPGA); the Laclede Group; and the Laclede Gas Company. This final rule summarizes and responds to the issues raised in these comments. A parenthetical reference [15] at the end of a comment quotation or paraphrase provides the location of the item in the public record.

A. Product Classes and Scope of Coverage

When evaluating and establishing energy conservation standards, DOE divides covered products into product classes by the type of energy used or by capacity or other performance-related features that justify differing standards. In making a determination whether a performance-related feature justifies a different standard, DOE must consider such factors as the utility of the feature to the consumer and other factors DOE determines are appropriate. (42 U.S.C. 6295(q))

Existing energy conservation standards divide residential boilers into six product classes based on the fuel type (*i.e.,* gas, oil, or electricity) and heating medium of the product (*i.e.,* hot water or steam). For this rulemaking, DOE maintains the scope of coverage defined by its current regulations for the analysis of standards, so as to include six product classes of boilers: (1) Gas-fired hot water boilers; (2) gas-fired steam boilers; (3) oil-fired hot water boilers; (4) oil-fired steam boilers; (5) electric hot water boilers; and (6) electric steam boilers. DOE has not conducted an analysis of an AFUE standard level for electric boilers, as the AFUE of these products already approaches 100 percent. DOE also did not conduct an analysis of a standard level for combination appliances, as the DOE test procedure does not include a method with which to test these products. These reasons are explained in greater detail in section IV.A.1 of this final rule. However, DOE did include electric boilers within the scope of its analysis of standby mode and off mode energy conservation standards.

The scope and product classes analyzed for this final rule are the same as those initially set forth in the Framework Document and examined in DOE's initial analysis, as well as what was proposed in the NOPR. Comments received relating to the scope of coverage are described in section IV.A of this final rule.

B. Test Procedure

DOE's current energy conservation standards for residential boilers are expressed in terms of AFUE (*see* 10 CFR 430.32(e)(2)(ii)). AFUE is an annualized fuel efficiency metric that fully accounts for fossil-fuel energy consumption in active, standby, and off modes. The existing DOE test procedure for determining the AFUE of residential boilers is located at 10 CFR part 430, subpart B, appendix N. The current DOE test procedure for residential boilers was originally established by a May 12, 1997 final rule, which incorporates by reference the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE)/American National Standards Institute (ANSI) Standard 103–1993, *Method of Testing for Annual Fuel Utilization Efficiency of Residential Central Furnaces and Boilers* (1993). 62 FR 26140, 26157.

On October 20, 2010, DOE updated its test procedures for residential boilers in a final rule published in the **Federal Register** (October 2010 test procedure final rule). 75 FR 64621. This rule amended DOE's test procedure for residential furnaces and boilers to establish a separate metric for measuring the electrical energy use in standby mode and off mode for gas-fired, oil-fired, and electric boilers pursuant to requirements established by EISA 2007. In the final rule, DOE determined that due to the magnitude of the electrical standby/off mode versus active mode, a single efficiency metric is technically infeasible. The test procedure amendments were primarily based on and incorporate by reference provisions of the International Electrotechnical Commission (IEC) Standard 62301 (First Edition), ''Household electrical appliances—Measurement of standby power.'' On December 31, 2012, DOE published a final rule in the **Federal Register** that updated the incorporation by reference of the standby mode and off mode test procedure provisions to refer to the latest edition of IEC Standard 62301 (Second Edition). 77 FR 76831.

On July 10, 2013, DOE published a final rule in the **Federal Register** (July 2013 final rule) that modified the existing testing procedures for residential furnaces and boilers. 78 FR 41265. The modification addressed the omission of equations needed to calculate AFUE for two-stage and modulating condensing furnaces and boilers that are tested using an optional procedure provided by section 9.10 of ASHRAE 103–1993 (incorporated by reference into DOE's test procedure), which allows the test engineer to omit the heat-up and cool-down tests if certain conditions are met. Specifically, the DOE test procedure allows condensing boilers and furnaces to omit the heat-up and cool-down tests, provided that the units have no measurable airflow through the combustion chamber and heat exchanger (HX) during the burner off period and have post-purge period(s) of less than 5 seconds. For two-stage and modulating condensing furnaces and boilers, ASHRAE 103–1993 (and by extension the DOE test procedure) does not contain the necessary equations to calculate the heating seasonal efficiency (which contributes to the ultimate calculation of AFUE) when the option in section 9.10 is selected. The July 2013 final rule adopted two new equations needed to account for the use of section 9.10 for two-stage and modulating condensing furnaces and boilers. *Id.*

EPCA, as amended by EISA 2007, requires that DOE must review test procedures for all covered products at least once every 7 years. (42 U.S.C 6293(b)(1)(A)) Accordingly, on March 11, 2015, DOE published a NOPR for the test procedure in the **Federal Register** (March 2015 test procedure NOPR), a necessary step toward fulfillment of the requirement under 42 U.S.C. 6293(b)(1)(A) for residential furnaces and boilers. 80 FR 12876. After a stakeholder comment and review period, DOE published a final rule for the test procedure in January 2016 (January 2016 test procedure final rule). (See EERE–2012–BT–TP–0024). DOE must base the analysis of amended energy conservation standards on the most recent version of its test procedures, and accordingly, DOE used the amended test procedure when considering product efficiencies, energy use, and efficiency improvements in its analyses. Major changes adopted in the January 2016 test procedure final rule included:

- Clarifying the definition of the electrical power term PE;
- Adopting a smoke stick test for determining the use of minimum default draft factors;

[15] The parenthetical reference provides a reference for information located in the docket of DOE's rulemaking to develop energy conservation standards for residential boilers. (Docket No. EERE–2012–BT–0047, which is maintained at *http://www.regulations.gov/#!docketDetail;D=EERE-2012-BT-STD-0047*). The references are arranged as follows: (commenter name, comment docket ID number, page of that document).

• Allowing for the measurement of condensate under steady-state conditions;
• Referencing the manufacturer's installation and operations (I&O) manual and providing clarification if the I&O manual does not specify test set up;
• Specifying ductwork for units installed without a return duct;
• Specifying testing requirements for units with multiposition configurations; and
• Revising the required reporting precision for AFUE.
• Adopting a verification method for determining whether a boiler incorporates an automatic means for adjusting water temperature and whether this design requirement functions as required.

DOE received several comments from stakeholders relating to the residential furnace and boiler test procedure. These comments were considered and addressed in that rulemaking proceeding.

C. Technological Feasibility

1. General

In each energy conservation standards rulemaking, DOE conducts a screening analysis based on information gathered on all current technology options and prototype designs that could improve the efficiency of the products or equipment that are the subject of the rulemaking. As the first step in such an analysis, DOE develops a list of technology options for consideration in consultation with manufacturers, design engineers, and other interested parties. DOE then determines which of those means for improving efficiency are technologically feasible. DOE considers technologies incorporated in commercially-available products or in working prototypes to be technologically feasible. 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, it is DOE policy not to include in its analysis any proprietary technology that is a unique pathway to achieving a certain efficiency level. Section IV.B of this notice discusses the results of the screening analysis for residential boilers, particularly the designs DOE considered, those it screened out, and those that are the basis for the standards in this rulemaking. For further details on the screening analysis for this rulemaking, see chapter 4 of the final rule technical support document (TSD).

2. Maximum Technologically Feasible Levels

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

D. Energy Savings

1. Determination of Savings

For each trial standard level (TSL), DOE projected energy savings from application of the TSL to residential boilers purchased in the 30-year period that begins in the year of compliance with any amended standards (2021–2050).[16] [17] The savings are measured over the entire lifetime of products purchased in the 30-year analysis period.[18] DOE quantified the energy savings attributable to each TSL as the difference in energy consumption between each standards case and the no-new-standards case. The no-new-standards case represents a projection of energy consumption that reflects how the market for a product would likely evolve in the absence of amended energy conservation standards, and it considers market forces and policies that affect demand for more-efficient products.

DOE used its national impact analysis (NIA) spreadsheet model to estimate national energy savings (NES) from potential amended standards for residential boilers. The NIA spreadsheet model (described in section IV.H of this final rule) calculates energy savings in terms of site energy, which is the energy directly consumed by products at the locations where they are used. For electricity, DOE calculates NES on an annual basis in terms of primary energy [19] 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, 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. For more information on FFC energy savings, see section IV.H.2 of this notice. For natural gas, the primary energy savings are considered to be equal to the site energy savings.[20]

2. Significance of Savings

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

[16] The expected compliance year at the time of the NOPR was 2020. For the final rule, the expected compliance year is 2021.

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

[18] In the past, DOE presented energy savings 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.

[19] 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.

[20] U.S. Energy Information Administration/Annual Energy Review 2011, Glossary, p.365 (Available at: *http://www.eia.gov/totalenergy/data/annual/pdf/sec18.pdf*).

Council v. *Herrington,* 768 F.2d 1355, 1373 (D.C. Cir. 1985), opined that Congress intended ''significant'' energy savings in the context of EPCA to be savings that are not ''genuinely trivial.'' The energy savings for all the TSLs considered in this rulemaking, including the adopted standards, are nontrivial, and, therefore, DOE considers them ''significant'' within the meaning of section 325 of EPCA.

E. Economic Justification

1. Specific Criteria

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

a. Economic Impact on Manufacturers and Consumers

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

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

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

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

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

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

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

c. Energy Savings

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

d. Lessening of Utility or Performance of Products

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

e. Impact of Any Lessening of Competition

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

f. Need for National Energy Conservation

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

The adopted 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 and use. DOE conducts an emissions impacts analysis to estimate how potential standards may affect these emissions, as discussed in section IV.K; the emissions impacts are reported in section V.B.6 of this final rule. DOE also estimates the economic value of emissions reductions resulting from the considered TSLs, as discussed in section IV.L.

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. 6295(o)(2)(B)(i)(VII)) To the extent interested parties submit any relevant information regarding economic justification that does not fit into the other categories described above, DOE could consider such information under ''other factors.'' For this final rule, DOE did not consider other factors.

2. Rebuttable Presumption

As set forth in 42 U.S.C. 6295(o)(2)(B)(iii), EPCA creates a rebuttable presumption that an energy conservation standard is economically justified if the additional cost to the consumer of a product that meets the standard is less than three times the value of the first year's energy savings resulting from the standard, as calculated under the applicable DOE test procedure. DOE's LCC and PBP analyses generate values used to calculate the effect potential amended energy conservation standards would have on the payback period for consumers. These analyses include, but are not limited to, the 3-year payback period contemplated under the rebuttable-presumption test. In addition, DOE routinely conducts an economic analysis that considers the full range of impacts to consumers, manufacturers, the Nation, and the environment, as required under 42 U.S.C. 6295(o)(2)(B)(i). The results of this analysis serve as the basis for DOE's evaluation of the economic justification for a potential standard level (thereby supporting or rebutting the results of any preliminary determination of economic justification). The rebuttable presumption payback calculation is discussed in section V.B.1 of this final rule.

F. General Comments

During the April 30, 2015 public meeting, and in subsequent written comments in response to the March 2015 NOPR, stakeholders provided input regarding general issues pertinent to the rulemaking, such as issues regarding the proposed standard levels, as well as issues related to changes made to the test procedure. These issues are discussed in this section.

1. Proposed Standard Levels

In response to the levels proposed in the NOPR (TSL 3), the joint efficiency commenters stated their support for the proposed standard levels and encouraged DOE to evaluate condensing levels for hot water boilers, noting that the national energy savings at TSL 4 would be more than five times greater than the savings at TSL 3. (The joint efficiency commenters, No. 62 at pp. 1–2)

AHRI, Burnham, Lochinvar, Weil-McLain, and PHCC stated their opposition to the proposed standards at TSL 3 based on their concerns about several areas within the analysis. (AHRI, No. 64 at p. 1; Burnham, No. 60 at p. 1; Lochinvar, No. 63 at p. 1; Weil-McLain, No. 55 at p. 1; PHCC, No. 61 at p. 1) Lochinvar encouraged DOE to consider adopting TSL 2, and PHCC suggested that DOE make minimal increases (one percentage point) to standards. (Lochinvar, No. 63 at p. 5; PHCC, No. 61 at p. 1) AHRI and Lochinvar also suggested that the efficiency levels presented in the NOPR at TSL 4 are not economically justified as minimum standards. (AHRI, No. 64 at p. 1; Lochinvar, No. 63 at p. 5)

Burnham stated that under the proposed standards, tens of thousands of consumers will lose choice, be effectively required to retain and repair old, inefficient units, or be forced into costly and even dangerous retrofits. (Burnham, No. 60 at p. 1) Burnham stated that DOE's proposed standards are based in part on energy use characterizations, installation costs, operating costs, and lifecycle costs which are flawed and tend to overstate the benefit of the proposed standards, and thereby, they do not meet EPCA's requirements of maximum improvements in energy efficiency that are technologically feasible and economically justified. Burnham stated that after correcting for the various technical issues, the LCC savings for 85-percent AFUE and higher gas-fired hot water boilers decrease substantially, even becoming negative. (Burnham, No. 60 at pp. 2, 4) Burnham stated that the DOE analysis either needs to be reanalyzed or that DOE needs to set standards for gas-fired hot water boilers at a level below 85-percent AFUE. (Burnham, No. 60 at p. 20)

Weil-McLain stated that significant additional costs will be imposed on consumers to achieve a hypothetical increase in energy savings by installing an 85-percent AFUE gas hot water boiler rather than an 82- or 83-percent AFUE boiler that would not entail all of these additional costs. (Weil-McLain, No. 55 at p. 3)

U.S. Boiler stated that a better alternative to the proposed rule would be to set a minimum efficiency level of 83 percent AFUE, which would allow most existing chimneys to stay in use without alteration. U.S. Boiler stated that such a standard gives homeowners choices regarding installation of higher-efficiency boilers. (U.S. Boiler, Public Meeting Transcript, No. 50 at p. 291)

ACCA stated that, if not properly addressed, the issues with the analysis can lead to unintended consequences, such as driving some homeowners to repair and maintain older systems instead of replacing their equipment. (ACCA, No. 65 at p. 3)

The Department appreciates stakeholder comments with regard to the TSL selection and notes that DOE is required to set a standard that achieves the maximum energy savings that is determined to be technologically feasible and economically justified. In making such a determination, DOE must consider, to the extent practicable, the benefits and burdens based on the seven criteria described in EPCA (see 42 U.S.C. 6295(o)(2)(B)(i)(I)–(VII)). DOE's weighing of the benefits and burdens based on the final rule analysis and rationale for the TSL selection is discussed in section V. DOE notes that much of the commentary regarding the selection of TSL levels for the standards is based on more detailed comments regarding specific portions of the final rule analysis. These comments related to specific analyses are addressed within the specific analysis section to which they pertain. However, as a general matter, DOE notes that in light of the comments and data provided by stakeholders, the agency carefully reexamined its data and analyses for residential boilers, ultimately reassessing the appropriate efficiency levels for some product classes. Specifically, DOE determined to adopt a standard level at 84-percent AFUE for gas-fired hot water boilers and 85-percent AFUE for oil-fired steam boilers, which DOE determined meet the criteria for TSL 3 without causing harms described by the stakeholders. Regarding safety issues at 84-percent

AFUE for gas-fired hot water boilers, DOE determined that at this efficiency, there is no difference in terms of their ability to meet minimum NFGC safety requirements, as compared to 82-percent and 83-percent AFUE models. Section III.F.3 further discusses the 84-percent efficiency level safety considerations. In regards to 85-percent AFUE for oil-fired steam boilers, such efficiency level results in oil-fired steam boilers being one AFUE point lower than the oil-fired hot water boilers standards, which is at 86-percent AFUE. This addresses stakeholder concerns about manufacturing burden associated with having separate tooling for oil-fired steam models and for oil-fired hot water models, because as AHRI noted, an oil-fired steam boiler will operate slightly less efficiently than an oil-fired hot water boiler of the same design. (AHRI No. 67, at p. 2) DOE reviewed the oil-fired boiler market, and found that a 1-percent AFUE difference between oil-fired steam and hot water boilers is typical, so the adopted standards of 86-percent AFUE for oil-fired hot water boilers and 85-percent AFUE for oil-fired steam boilers will allow manufacturers to maintain one design for both oil-fired steam and oil-fired hot water boilers. Results are discussed further in section V of this document and in the final rule TSD.

2. Simultaneous Changes in Test Procedures and Energy Conservation Standards

Several stakeholders expressed legal, procedural, and practical concerns regarding the timing of the proposed test procedures and energy conservation standards revisions for residential boilers. Several stakeholders requested that DOE delay any further work on the rulemakings to amend efficiency standards for residential boilers until after the finalization of the test procedure. (AHRI, No. 64 at p. 2; Lochinvar, No. 63 at p. 1; Burnham, No. 60 at p. 5; AGA/APGA, No. 54 at p. 11; ACCA, No. 65 at p. 1) Specifically, AHRI requested that DOE reopen the docket for the March 2015 residential boiler standards NOPR once the test procedure has been finalized. (AHRI, No. 64 at p. 2) AHRI argued that the non-final status of the test procedure inhibits stakeholders' fair evaluation of the proposed standards and stressed the importance of having a known efficiency test procedure. AHRI commented that when a test procedure is in flux, manufacturers must spend resources collecting potentially unusable data which undermines their ability to effectively provide input on the proposed efficiency standards. Similarly, AHRI added that when a test procedure is not finalized, a manufacturer has no way of determining whether the test procedure will affect its ability to comply with a proposed revised standard. (AHRI, No. 64 at p. 2)

Many of these commenters were concerned about the timing of the energy conservation standards and test procedures rulemakings, given their expectation that the proposed changes to the test procedures for residential boilers would result in changes to the AFUE rating metric. Specifically, AHRI, Burnham, and Weil-McLain stated that the changes to the test procedure presented in the March 2015 TP NOPR would result in significant changes to the AFUE measurement. (AHRI, No. 64 at p. 1; Burnham, No. 60 at p. 6; Weil-McLain, No. 55 at p. 7) Burnham noted that the fact that the test procedure rulemaking is ongoing makes it impossible to gauge the effects of its final rule on proposed energy conservation standards. (Burnham, No. 60 at p. 6) AHRI stated that the proposed test procedure, if finalized, is not neutral and will require an adjustment of the AFUE standard to accommodate for the test effects. AHRI disagreed with DOE's tentative determination in the March 2015 TP NOPR that the proposed updates to the AFUE test method would not affect the AFUE ratings. AHRI stated that test data it is collecting shows that the proposed test procedure changes the resulting AFUE measurement. AHRI noted that one such change affecting AFUE is the proposed change to the procedure for burner set-up. (AHRI, No. 64 at p. 3)

Several stakeholders also contended that the timing of the test procedures and standards rulemakings violated certain procedural requirements, or DOE's own procedural policies. Burnham asserted that the simultaneous test procedure and standards rulemaking raises concerns under the Data Quality Act, and stated that the law and OMB guidelines require agency actions aimed at ''maximizing the quality, objectivity, utility, and integrity of information (including statistical information) disseminated by the agency.'' Burnham commented that DOE has considerable work ahead to comply with this requirement, and cited section 515 of the Treasury and General Government Appropriations Act for Fiscal Year 2001 (Pub. L. 106–554; HR 5658) at section 515(b)(2)(a). (Burnham, No. 60 at pp. 3, 6) AHRI, ACCA, and Burnham stated that by publishing the March 2015 TP NOPR within weeks of the proposed efficiency standards, DOE has failed to abide by its codified procedures at 10 CFR part 430, subpart C, appendix A(7)(c). (AHRI, No. 64 at p. 2; ACCA, No. 65 at p. 1; Burnham, No. 60 at p. 6) AHRI stated that The Administrative Procedure Act (APA) requires agencies to abide by their policies and procedures, especially where those rules have a substantive effect, and that the non-final test procedure has the substantive effect of increasing costs to stakeholders and diminishing their ability to comment on the efficiency standards. (AHRI, No. 64 at p. 2) AHRI noted that DOE is required to give stakeholders the opportunity to provide meaningful comments (see 42 U.S.C. 6295(p)(2), 6306(a)), and asserted that the close timing of the test procedures and standards NOPRs diminishes that opportunity. (AHRI, No. 64 at p. 2)

DOE does not believe that the timing of the test procedure and standards rulemakings has negatively impacted stakeholder's ability to provide comment. DOE has afforded interested parties an opportunity to provide comment on both the residential boiler standards rulemaking and the residential furnace and boiler test procedure rulemaking, consistent with the requirements of EPCA and all other relevant statutory provisions. Further, given the publication of the boilers test procedure final rule and the fact that none of the adopted changes will impact AFUE, DOE has determined it is not necessary to delay this standards rulemaking.

With regard to the specific concerns raised by stakeholders regarding changes to the AFUE metric, DOE determined in the March 2015 TP NOPR that the proposed test procedure amendments would have a *de minimis* impact on products' measured efficiency. 80 FR 12876, 12878 (March 11, 2015). However, as discussed above, DOE received comments from stakeholders both in response to the March 2015 test procedure NOPR and to the March 2015 standards NOPR suggesting that several provisions within the March 2015 test procedure NOPR would significantly impact AFUE ratings. In the January 2016 test procedure final rule, DOE responded to each of these comments and ultimately did not adopt those provisions which were suggested to cause changes to the AFUE ratings. The specific comments and proposals that were and were not adopted are discussed in detail in the January 2016 TP final rule. As discussed in the January 2016 TP final rule, because DOE ultimately did not adopt the proposed changes that were suggested to impact the AFUE ratings, the Department has concluded that all of the recent updates to the test procedure will have a *de minimis* impact on AFUE ratings. Furthermore, DOE is adopting its amended and new standards for residential boilers based upon use of the revised test procedures, so any changes to the test procedure that could affect measured energy efficiency were fully taken into account in those standards.

Second, with regard to Burnham's assertion that DOE has not met the requirements of the Data Quality Act (DQA), DOE does not believe that the timing of the test procedure and standards rulemakings are matters within the Department's guidelines implementing the DQA. DOE has concluded that the data, analysis, and models it has used in this rulemaking adhered to the requirements of the Data Quality Act. Further, DOE strived to maximize the quality, objectivity, utility, and integrity of the information disseminated in this rulemaking (see section VI.J for more information on these requirements and DOE's determination). As noted above, the January 2016 test procedure final rule removed all of the provisions within the March 2015 test procedure NOPR that could significantly impact AFUE ratings.

Finally, with regard to the comments stating that DOE has failed to abide by its codified procedures at 10 CFR 430, subpart C, appendix A (7)(c), Appendix A establishes procedures, interpretations, and policies to guide DOE in the consideration and promulgation of new or revised appliance efficiency standards under EPCA. (See section 1 of 10 CFR 430 subpart C, appendix A) Those procedures are a general guide to the steps DOE typically follows in promulgating energy conservation standards. The guidance recognizes that DOE can and will, on occasion, deviate from the typical process. Accordingly, DOE has concluded that there is no basis to delay the final rule adopting standards for residential boilers.

3. Safety Issues

Lochinvar stated that the DOE analysis does not account for the impact of the proposed residential boiler standards on public safety. Specifically, Lochinvar stated that if 85–percent AFUE becomes the standard for gas-fired hot water boilers, the likelihood that the boilers will consistently have proper product installations and venting system design diminishes. (Lochinvar, No. 63 at p. 5) AHRI stated that the consumer safety impacts should eliminate consideration of a minimum efficiency standard appreciably above the current minimum standards for gas-fired and oil-fired boilers. (AHRI, No. 64 at pp. 3–4) Burnham stated that consumer safety hazards, along with the imposition of liability on manufacturers concordant with such safety hazards, alone justify the exclusion of Category I gas boilers at the 85–percent and 84–percent efficiency levels. (Burnham, No. 60 at p. 13)

Burnham stated that an 85–percent AFUE standard will risk hazards associated with old products being left in service long after it should be replaced due to higher replacement costs, and old boilers being replaced by less safe alternatives such as kerosene heaters. (Burnham, No. 60 at p. 3) Burnham stated that for 85–percent AFUE boilers, there are too many potential installations which breach acceptable safety levels. Furthermore, low-income consumers who do not have the resources to afford the necessary venting system upgrades required with condensing or near-condensing products will be imperiled. (Burnham, No. 60 at p. 7)

Burnham also stated that by selecting an 85–percent AFUE standard for gas-fired hot water boilers, DOE is risking carbon monoxide poisoning in situations where there are venting approaches used that meet building codes but which may not be adequate for full safety. (Burnham, No. 60 at pp. 3–4) Lochinvar stated that the condensation of flue gasses in venting will corrode conventional venting and may lead to spilling carbon monoxide into occupied spaces and death. (Lochinvar, No. 63 at p. 3)

Weil-McLain stated that the issues associated with the proposed retrofit venting requirements also create a potential safety hazard because positive pressure venting could push flue gases into the building. (Weil-McLain, No. 55 at p. 3) ACCA and Weil-McLain stated that there will be some less-skilled installers or do-it-yourselfers who may install the higher efficiency models incorrectly, resulting in safety problems. (ACCA, No. 65 at pp. 2–3; Weil-McLain, No. 55 at p. 3)

AHRI stated that the results of the analysis done by Gas Technology Institute (GTI), as contained in a report prepared for AHRI using a Vent-II tool, show that at an 84–percent or 85–percent AFUE level, the potential for excessive wetting in the vent system increases. As explained in the report, the ''wet time'' limits are values that have been used to establish the coverage for properly sized and configured vent systems for atmospheric gas-fired boilers in the National Fuel Gas Code (NFGC). When the Vent-II analysis shows wet times exceeding these limits, it is an indication of excessive condensation which increases the potential for condensate-induced corrosion and subsequent vent system failure, resulting in safety problems. (AHRI, No. 67 at p. 1)

In response, DOE has concluded that manufacturers will provide adequate guidance for installers to ensure that the venting system is safe. Furthermore, DOE assumed that 85–percent AFUE boilers would either be Category I or Category III appliances, and DOE accounted for a fraction of installations that would require a stainless steel vent connector or stainless steel venting to mitigate the dangers of potential corrosion issues. In any case, DOE is not adopting a standard at 85–percent AFUE for gas-fired boilers, so the potential problems raised by the stakeholders will not be an issue.

Regarding safety issues at to 84–percent AFUE, based on Burnham's data, AHRI's contractors' survey, and models available in the AHRI directory, DOE determined that the fraction of shipments and model availability with mechanical draft for the 82–percent to 84–percent AFUE boilers is about the same. In addition, AHRI's Vent-II analysis showed that for all 21 different scenario cases, 82–percent to 84–percent AFUE boilers demonstrated no difference in terms of their ability to meet the dryout wet times required to achieve the minimum NFGC safety requirements.[21]

4. Other

The Laclede group stated that DOE is not adhering to the process transparency and scientific integrity policies as set forth in 1996 ''Process Improvement Rule'' and outlined in 10 CFR 430, subpart C, appendix A (7)(g). 61 FR 36974 (July 15, 1996). Laclede also asserted that through the inconsistent application of the process improvement rule, DOE is not adhering to the consistency and transparency requirements outlined in the Treasury and General Government Appropriations Act of 2001, the Paperwork Reduction Act of 1995 (primarily Section 515), and the ''Presidential Scientific Integrity Memorandum'' issued on March 9, 2009, which was further clarified by the Director of the Office of Science and Technology Policy ''Memorandum to the Heads of Departments and Agencies'' of December 17, 2010. (Laclede, No. 58 at pp. 7–9)

[21] National Fire Protection Association, *NFPA 54 (ANSI Z223.1): National Fuel Gas Code* (2015) (Available at: *http://www.nfpa.org/codes-and-standards/document-information-pages?mode=code&code=54*).

As discussed in sections VI.C, J, and L and illustrated elsewhere in this document, DOE has developed analytical processes and data that ensure the quality of its information and the transparency of its analytical processes. In furtherance of these objectives and requirements, DOE has offered several opportunities for public comment on multiple documents, including documents made available prior to proposing any rule, and addressed stakeholder concerns at the April 30, 2015 public meeting, providing clarifications in an open and transparent fashion.

The Laclede group also stated that DOE failed to meet the requirements of Executive Order 12866, ''Regulatory Planning and Review,'' through the refusal to consider the alternative of not regulating. (Laclede, No. 58 at p. 7) DOE considered alternatives to regulating, including no new regulatory action. A full discussion of the non-regulatory alternatives considered by DOE is presented in the regulatory impact analysis found in chapter 17 of the final rule TSD.

As discussed previously, DOE believes it is in compliance with the requirements of 515 of the Treasury and Gen. Government Appropriations Act for fiscal year 2001 (Public Law 106–554; HR 5658) at section 515(b)(2)(a). (See section VI.J of this document.) For the final rule stage, DOE has incorporated feedback from interested parties, as appropriate, related to the energy use characterization, installation costs, operating costs, and lifecycle costs, leading to revisions in this analysis as compared to the analysis presented for the March 2015 NOPR. The specific comments and any related revisions are discussed in more detail in the applicable subsections of section IV of this document.

AHRI stated that DOE bears the burden, on the basis of substantial evidence, to demonstrate that the proposed standards are technologically feasible and economically justified. AHRI claimed that the DOE has attempted to impermissibly shift its statutory burden of data production onto stakeholders by forcing them to disprove several unreasonable assumptions including the price elasticity of boilers, as well as the lifetime of condensing boilers. AHRI stated that at a minimum, DOE has the responsibility to explain the basis for its assumptions. (AHRI, No. 64 at p. 4)

In response to AHRI, DOE notes that it conducts its analyses with the best available information that it is aware of, and seeks comment from interested parties as a way to ensure analytical robustness and verify the accuracy of the assumptions and information used in the rulemaking process. DOE then revises its analyses based on comments, information, and data collected through additional research and presented by stakeholders, as applicable, in later rulemaking stages. In some cases, additional relevant but unpublished data may reside with the regulated community and can be considered by DOE only if provided by those regulated parties. DOE has provided detailed comment responses regarding the specific assumptions outlined by AHRI in sections IV.F.2.d and IV.G.

In response to the NOPR, Weil-McLain stated that DOE had changed its position outlined in the NODA to not amend energy conservation standards for residential boilers. Weil-McLain added that DOE did so without explanation for the change in recommendation. (Weil-McLain, No. 55 at p.8)

In response, DOE emphasizes that the 2014 NODA was not a determination on whether to amend standards for residential boilers. Rather, it was a publication of the analysis and results at a preliminary stage (*i.e.,* before the NOPR) so that stakeholders could review and comment on the analytical output, the underlining assumptions, and the calculations that may ultimately be used to support amended standards. The DOE statement to which Weil-McLain refers is correct in that the 2014 NODA did not propose any amendments to the standards because at that early stage, DOE was not prepared to do so. It was not a statement that it had determined not to propose standards. Therefore, DOE did not change its position from the publication of the 2014 NODA to the publication of the 2015 NOPR.

IV. Methodology and Discussion of Related Comments

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

DOE used several analytical tools to estimate the impact of the standards considered in this document. The first tool is a spreadsheet that calculates the LCC and PBP of potential amended or new energy conservation standards. The national impact analysis uses a second spreadsheet set that provides shipments forecasts and calculates national energy savings and net present value of total consumer costs and savings expected to result from potential energy conservation standards. DOE uses the third spreadsheet tool, the Government Regulatory Impact Model (GRIM), to assess manufacturer impacts of potential standards. These spreadsheet tools are available on the DOE Web site for this rulemaking at: *http://www1.eere.energy.gov/buildings/appliance_standards/rulemaking.aspx?ruleid=112*. Additionally, DOE used output from the latest version of EIA's *Annual Energy Outlook* (*AEO*), a widely known energy forecast for the United States for the emissions and utility impact analyses.

A. Market and Technology Assessment

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

1. Scope of Coverage

In the NOPR, DOE proposed to maintain the scope of coverage as defined by its current regulations for this analysis of new and amended standards, which includes six product classes of residential boilers: (1) Gas-fired hot water boilers, (2) gas-fired steam boilers, (3) oil-fired hot water boilers, (4) oil-fired steam boilers, (5) electric hot water boilers, and (6) electric steam boilers. As discussed in further detail in the paragraphs below, DOE excluded several types of residential boilers from the analysis in both the March 2015 NOPR and, subsequently, in this final rule.

DOE did not consider combination space and water heating appliances for this final rule. Combination appliances provide both space heating and domestic hot water to a residence. These products are available on the market in two major configurations, including a water heater fan-coil combination unit and a boiler tankless coil combination unit. Currently, manufacturers certify combination appliances by rating the efficiency of the unit when performing their primary function (*i.e.,* space heating for boiler tankless coil combination units or water heating for water heater fan-coil units). As explained in the March 2015 NOPR, DOE proposed to exclude such products from the analysis conducted for this rulemaking. 80 FR 17222, 17238 (March 31, 2015). DOE did not receive any comments related to the coverage of combination appliances, and, thus, has not include them in this final rule.

DOE did not include electric boilers in the analysis of amended AFUE standards. (However, DOE has considered standby mode and off mode standards for electric boilers.) Electric boilers do not currently have an AFUE requirement under 10 CFR 430.32(e)(2)(ii). Electric boilers typically use electric resistance coils as their heating elements, which are highly efficient. Furthermore, the current DOE test procedure for determining AFUE classifies boilers as indoor units and, thus, considers jacket losses to be usable heat, because those losses would go to the conditioned space. The efficiency of these products already approaches 100 percent AFUE. Therefore, there are no options for increasing the rated AFUE of this product, and the impact of setting AFUE energy conservation standards for these products would be negligible. DOE proposed not to analyze amended AFUE standards for electric boilers in the March 2015 NOPR and did not receive any comments relating to this proposal. 80 FR 17222, 17238 (March 31, 2015).

DOE also did not include boilers that are manufactured to operate without the need for electricity in the analysis of amended AFUE standards. As was noted in the March 2015 NOPR, an exception already exists for boilers which are manufactured to operate without any need for electricity. (42 U.S.C. 6295(f)(3)(C); 10 CFR 430.32(e)(2)(iv)) 80 FR 17222, 17238 (March 31, 2015). Thus, DOE did not consider such products in the course of this analysis, and such products are not covered by the amended standards. DOE did not receive any comments in response to its proposal to exclude these products in the March 2015 NOPR.

In summary, DOE did not receive any comments in response to the NOPR regarding scope of coverage. Therefore, the scope used for the analysis of this final rule is the same as the scope used for the NOPR analysis.

2. Product Classes

When evaluating and establishing energy conservation standards, DOE divides covered products into product classes by the type of energy used or by capacity or other performance-related features that justify a different standard. In making a determination whether a performance-related feature justifies a different standard, DOE must consider such factors as the utility to the consumer of the feature and other factors DOE determines are appropriate. (42 U.S.C. 6295(q)) For this rulemaking, as discussed in the preceding section, DOE proposes to maintain the scope of coverage as defined by its current regulations for this analysis of standards, which includes six product classes of boilers. Table IV.1 lists the six product classes examined in the final rule.

TABLE IV.1—PRODUCT CLASSES FOR RESIDENTIAL BOILERS

Boiler by fuel type	Heat transfer medium
Gas-fired Boiler	Steam. Hot Water.
Oil-fired Boiler	Steam. Hot Water.
Electric Boiler	Steam. Hot Water.

In response to the proposed product classes included in the March 2015 NOPR, AGA, APGA, and PGW requested that DOE establish separate product classes for residential condensing and non-condensing boilers. (AGA, No. 54 at p. 11; PGW, No. 57 at p. 2) AGA stated that non-condensing boilers provide customers unique performance-related characteristics and consumer utility due to distinct venting characteristics and building constraints on installations. AGA stated that failure to adopt separate product classes would be inconsistent with DOE precedent. (AGA, No. 54 at p. 6)

Burnham stated that loss of the ability to use Category I venting (suitable for non-condensing boilers) is a loss in utility because the circumstances of many real world installations offer no practical alternatives to Category I venting, particularly in urban areas with closely-spaced residences. Burnham argued that providing heat and hot water are not the only utility functions, features, and performance characteristics of boilers, and that designs that allow proper installation in a variety of dwellings are a critical aspect of utility so that such products can be installed and used safely. Burnham stated limited exterior wall space and building or safety code or physical restrictions on where exhaust terminals can be located can cause venting issues, and that these constraints can be a particular problem in urban areas with homes that are either closely spaced or conjoined. Burnham gave the example of older ''row homes'' found in Northeastern cities, which Burnham asserted represent a large part of the U.S. residential boiler market. (Burnham, No. 60 at p. 14) In addition, Burnham stated that there is a point at which increasing installation costs become large enough to effectively create a ''loss of utility,'' and this situation in the real world is as likely to ''result in the unavailability'' of appropriate non-condensing boilers as a pure design issue. Burnham stated that this is a direct violation of the ''safe harbor rule'' in 42 U.S.C. 6295(o)(4), among other provisions. (Burnham, No. 60 at pp. 4–16)

DOE received similar comments in response to the February 11, 2014 NODA and preliminary analysis, and addressed the comments in the March 31, 2015 NOPR. 79 FR 8122; 80 FR 17222. DOE maintains its position from the NOPR and reiterates that the utility derived by consumers from boilers is in the form of the space heating function that a boiler performs, rather than the type of venting the boiler uses. Condensing and non-condensing boilers perform equally well in providing this heating function. Likewise, a boiler requiring Category I venting and a boiler requiring Category IV venting are capable of providing the same heating function to the consumer, and, thus, provide virtually the same utility with respect to their primary function. DOE does not consider reduced costs associated with Category I venting in certain installations as a special utility, but rather, as was done in the March 2015 NOPR, the costs were considered as an economic impact on consumers that is considered in the rulemaking's cost-benefit analysis. DOE does not agree with Burnham's assertion that costs can become so prohibitively expensive that they should be considered a loss of utility of the product. Rather, the larger expense should be considered as an economic impact on consumers in the rulemaking's cost-benefit analysis and ultimately the analysis will determine if a cost is economically prohibitive. DOE considered the additional cost of adding vent length required to change the vent location to avoid the code limitations outlined by Burnham. Details regarding installation costs can be located in section IV.F.2. DOE maintains that this final rule is not in violation of the 42 U.S.C. 6295(o)(4), because it does not result in the unavailability of any covered product class of performance characteristics, features, sizes, capacities and volumes. DOE does not consider the type of venting to be a ''feature'' that would provide utility to consumers, other than the economic benefits of the venting type which are properly considered in the economic analysis.

3. Technology Options

As part of the market and technology assessment, DOE develops a comprehensive list of technologies to improve the energy efficiency of residential boilers. In the final rule analysis, DOE identified ten technology options that would be expected to improve the AFUE of residential boilers, as measured by the DOE test procedure: (1) Heat exchanger improvements; (2) modulating operation; (3) dampers; (4) direct vent; (5) pulse combustion; (6) premix burners; (7) burner derating; (8) low-pressure air-atomized oil burner; (9) delayed-action oil pump solenoid valve; and (10) electronic ignition.[22] In addition, DOE identified three technologies that would reduce the standby mode and off mode energy consumption of residential boilers: (1) Transformer improvements; (2) control relay for models with brushless permanent magnet motors; and (3) switching mode power supply.

DOE received no comments suggesting additional technology options in response to the NOPR analysis, and thus, DOE has maintained the same list of technologies in the final rule analysis. After identifying all potential technology options for improving the efficiency of residential boilers, DOE performed the screening analysis (see section IV.B of this final rule or chapter 4 of the final rule TSD) on these technologies to determine which could be considered further in the analysis and which should be eliminated.

B. Screening Analysis

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

1. *Technological feasibility.* Technologies that are not incorporated in commercial products or in working prototypes will not be considered further.

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

3. *Impacts on product utility or product availability.* If it is determined that a technology would have 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 be considered further.

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

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

In sum, if DOE determines that a technology, or a combination of technologies, fails to meet one or more of the above four criteria, it will be excluded from further consideration in the engineering analysis. Additionally, it is DOE policy not to include in its analysis any proprietary technology that is a unique pathway to achieving a certain efficiency level. The reasons for eliminating any technology are discussed below.

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

1. Screened-Out Technologies

During the NODA and NOPR phases, DOE screened out pulse combustion as a technology option for improving AFUE and screened out control relay for boiler models with brushless permanent magnet motors as a technology option for reducing standby electric losses. DOE decided to screen out pulse combustion based on manufacturer feedback during the Framework public meeting indicating that pulse combustion boilers have had reliability issues in the past, and therefore, manufacturers do not consider this a viable option to improve efficiency. Further, manufacturers indicated that similar or greater efficiencies than those of pulse combustion boilers can be achieved using alternative technologies. DOE did not receive any comments related to screening out pulse combustion and maintained this position for the final rule, and accordingly, maintained its position from the NOPR to screen out pulse combustion as a technology option.

In the NODA and NOPR analysis, DOE decided to screen out the option of using a control relay to depower BPM motors due to feedback received during the residential furnace rulemaking (which was reconfirmed during manufacturer interviews for the residential boiler rulemaking), which indicated that using a control relay to depower brushless permanent magnet motors could reduce the lifetime of the motors. The result of such a design would likely be excessively frequent repair and maintenance of the boiler to replace the motor.

DOE also screened out burner derating as a technology option in the NOPR and final rule analysis. Burner derating reduces the burner firing rate while keeping heat exchanger geometry and surface area and the fuel-air ratio the same, which increases the ratio of heat transfer surface area to energy input, and increases the efficiency. However, the lower energy input means that less heat is provided to the user than with conventional burner firing rates. As a result of the decreased heat output of the boiler with derated burners, DOE has screened out burner derating as a technology option, as it could reduce consumer utility.

The efficiency advocates recommended that DOE assess whether the de-powering could be done in a manner to minimize the number of power cycles to address concerns regarding potential product life impacts, for example by only disconnecting when the boiler has been inactive for more than 24 hours. The efficiency advocates suggested that this approach would achieve the desired results during long periods of inactivity, such as during the summer, without cycling on and off during periods of regular activity. (Efficiency Advocates, No. 62 at p. 2)

DOE has not found any residential boilers which utilize control relays to completely depower the BPM motors. The feedback received from the residential furnace rulemaking indicated that it was not only the number of power cycles which could reduce product utility but the potential for large current upon start up. Therefore, DOE has maintained its position from the NOPR in this final

[22] Although DOE has identified vent dampers and electronic ignition as technologies that improve residential boiler efficiency, DOE did not consider these technologies further in the analysis as options for improving efficiency of baseline units, because they are already included in baseline residential boilers.

rule and screened out control relays for models with brushless permanent magnet motors as a technology option, as it would reduce consumer utility. However, DOE will continue to evaluate this technology further in future rulemakings if motor technology develops that would allow for the inclusion of such a design.

2. Remaining Technologies

Through a review of each technology, DOE found that all of the other identified technologies met all four screening criteria and consequently, are suitable for further examination in DOE's analysis. In summary, DOE did not screen out the following technology options to improve AFUE: (1) heat exchanger improvements; (2) modulating operation; (3) direct vent; (4) premix burners; (5) low-pressure air-atomized oil burner; and (6) delayed-action oil pump solenoid valve. DOE also maintained the following technology options to improve standby mode and off mode energy consumption: (1) transformer improvements; and (2) switching mode power supply. All of these technology options are technologically feasible, given that the evaluated technologies are being used (or have been used) in commercially-available products or working prototypes. Therefore, all of the trial standard levels evaluated in this notice are technologically feasible. DOE also finds that all of the remaining technology options also meet the other screening criteria (*i.e.,* practicable to manufacture, install, and service, and do not result in adverse impacts on consumer utility, product availability, health, or safety). For additional details, please see chapter 4 of the final rule TSD.

C. Engineering Analysis

In the engineering analysis (corresponding to chapter 5 of the final rule TSD), DOE establishes the relationship between the manufacturer selling price (MSP) and improved residential boiler energy efficiency. This relationship serves as the basis for cost-benefit calculations for individual consumers, manufacturers, and the Nation. DOE typically structures the engineering analysis using one of three approaches: (1) design option; (2) efficiency level; or (3) reverse engineering (or cost-assessment). The design-option approach involves adding the estimated cost and efficiency of various efficiency-improving design changes to the baseline to model different levels of energy efficiency. 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. The reverse-engineering approach involves testing products for efficiency and determining cost from a detailed bill of materials (BOM) derived from the reverse-engineering of representative products. The efficiency values under consideration range from that of a least-efficient boiler sold today (*i.e.,* the baseline) to the maximum technologically feasible efficiency level. At each efficiency level examined, DOE determines the manufacturer production cost (MPC) and MSP; this relationship is referred to as a cost-efficiency curve.

As noted in section III.B, the AFUE metric fully accounts for the fossil-fuel energy consumption in active, standby and off modes, whereas the electrical energy consumption in standby mode and off mode is accounted for with separate metrics that measure the power drawn during standby mode and off mode ($P_{W,SB}$ and $P_{W,OFF}$ for standby mode and off mode, respectively). In analyzing the technologies that would likely be employed to effect changes in these metrics, DOE found that the changes that would be implemented to increase AFUE were mostly independent from the changes that would be implemented to reduce the electrical standby mode and off mode energy consumption ($P_{W,SB}$ and $P_{W,OFF}$). For example, the primary means of improving AFUE is to improve the heat exchanger design, which DOE expects would have little or no impact on standby mode and off mode electrical energy consumption. Similarly, the design options considered likely to be implemented for reducing standby mode and off mode electrical energy consumption are not expected to impact the AFUE. Therefore, DOE conducted separate engineering and cost-benefit analyses for the AFUE metric and the standby mode and off mode metrics and their associated systems (fuel and electrical). In order to account for the total impacts of both considered standards, DOE added the monetized impacts from these two separate analyses in the NIA, LCC, and MIA as a means of providing a cumulative impact of both residential boilers standards. For the PBP, to estimate the cumulative impact for both standards, DOE determined the combined installed cost to the consumer and the first-year operating costs for each household.

For the NOPR analysis of AFUE efficiency levels, DOE conducted the engineering analysis for residential boilers using a combination of the efficiency level and cost-assessment approaches. More specifically, DOE identified the efficiency levels for analysis and then used the cost-assessment approach to determine the technologies used and the associated manufacturing costs at those levels.

For the standby mode and off mode analyses, DOE adopted a design option approach, which allowed for the calculation of incremental costs through the addition of specific design options to a baseline model. DOE decided on this approach because it did not have sufficient data to execute an efficiency-level analysis, as manufacturers typically do not rate or publish data on the standby mode and or off mode energy consumption of their products.

DOE continued to use the same analytical approaches for the final rule as used in the NOPR. In response to the NOPR, DOE received specific comments from interested parties on certain aspects of the engineering analysis. A brief overview of the methodology, a discussion of the comments DOE received, and DOE's response to those comments, as well as any adjustments made to the engineering analysis methodology or assumptions as a result of those comments, are presented in the sections below. See chapter 5 of the final rule TSD for additional details about the engineering analysis.

1. Efficiency Levels

As noted previously, for analysis of amended AFUE standards, DOE used an efficiency-level approach to identify incremental improvements in efficiency for each product class. The efficiency-level approach enabled DOE to identify incremental improvements in efficiency for efficiency-improving technologies that boiler manufacturers already incorporate in commercially-available models. After identifying efficiency levels for analysis, DOE used a cost-assessment approach (section IV.C.2) to determine the MPC at each efficiency level identified for analysis. This method estimates the incremental cost of increasing product efficiency. For the analysis of amended standby mode and off mode energy conservation standards, DOE used a design-option approach and identified efficiency levels that would result from implementing certain design options for reducing power consumption in standby mode and off mode.

a. Baseline Efficiency Level and Product Characteristics

In its analysis, DOE selected baseline units typical of the least-efficient commercially-available residential boilers. DOE selected baseline units as reference points for each product class, against which it measured changes resulting from potential amended energy conservation standards. The baseline efficiency level in each product class represents the basic characteristics of products in that class. A baseline unit is a unit that just meets current Federal energy conservation standards and provides basic consumer utility.

DOE uses the baseline unit for comparison in several phases of the analyses, including the engineering analysis, LCC analysis, PBP analysis, and the NIA. To determine energy savings that will result from an amended energy conservation standard, DOE compares energy use at each of the higher energy efficiency levels to the energy consumption of the baseline unit. Similarly, to determine the changes in price to the consumer that will result from an amended energy conservation standard, DOE compares the price of a baseline unit to the price of a unit at each higher efficiency level.

DOE received no comments regarding the baseline efficiency levels chosen for the NOPR analysis of amended AFUE standards. Thus, DOE has maintained these baseline efficiency levels for the final rule analysis, which are equal to the current Federal minimum standards for each product class in the final rule analysis. Table IV.2 presents the baseline AFUE levels identified for each product class. Additional details on the selection of baseline AFUE efficiency levels are in chapter 5 of the final rule TSD.

TABLE IV.2—BASELINE AFUE EFFICIENCY LEVELS

Product class	AFUE (%)
Gas-Fired Hot Water Boilers	82
Gas-Fired Steam Boilers	80
Oil-Fired Hot Water Boilers	84
Oil-Fired Steam Boilers	82

The input capacity is a factor that influences the MPC of a residential boiler. The impact of efficiency ratings on residential boiler prices can be captured by calculating the incremental price for each efficiency level higher than the baseline at a given input capacity. To provide a singular set of incremental price results for the engineering analysis, DOE selected a single input capacity for each product class analyzed for AFUE standards. DOE selected these input capacities by referencing a number of sources, including information obtained during manufacturer interviews, information collected for the market and technology assessment, as well as information obtained from product literature.

In response to the representative input capacities selected in the engineering analysis from each product class, Burnham presented shipment information of their aggregated subsidiaries indicating the average input capacity sold in for each product class. Based upon this data, Burnham suggested that the representative input capacity for gas-fired hot water boilers should be changed to 120 kBtu/hr. (Burnham, No. 60 at p. 20)

In response, DOE notes that the representative input capacity is meant to describe the most typical boiler sold. Therefore, DOE believes that although the average of all shipments sold may be 120 kBtu/hr, the most often sold would be 100 kBtu/hr. AHRI stated that the analysis does not adequately evaluate the effect of revised efficiency standards on larger input boilers. AHRI stated that boilers are a very small segment of the U.S. residential heating market and commented that larger input boilers are the smallest segment of the residential boiler market. For these larger input models, AHRI argued that there is no economy of scale, and because relatively so few are manufactured, the costs of components are higher. The units are physically larger and weigh more so their shipping costs are larger. Accordingly, AHRI asserted that the information developed by the tear down analysis cannot be validly scaled up to these models which have input rates 2 to 2.5 times higher than the baseline models. (AHRI, No. 64 at p. 14) Similarly, Burnham stated that due to the size of the residential boiler market, the manufacturing costs for a 250,000 Btu/hr boiler may not be a simple linear scale. (Burnham, public meeting transcript, No. 50 at p. 34)

In response to these comments, DOE examined the parts catalogs of various manufacturers for a variety of boiler types within each product class. From this examination, DOE determined that the same materials, as well as purchase parts are utilized in the manufacture of both representative and larger capacity boilers. For example, a representative capacity heat exchanger may be comprised of four cast iron sections, including two end sections with two intermediate sections. A larger capacity unit would generally be comprised of a larger number of the same sections, typically two end sections with six intermediate sections for a 250 kBtu/hr boiler. Although the amount of material used increases as capacity increases, DOE has not found reason to believe that the cost of the material would increase due to a lack of economy of scale.

In addition, DOE found that the large majority of components used for larger-capacity boilers were identical to those used in lower capacity boilers, although larger quantities of those components may be necessary in the manufacturing of higher-capacity boilers. For example, a larger-capacity burner may require a larger number of burner tubes. In several cases, the cost of the higher-capacity unit could be expected to be less than the result of a linear scaling upward of the cost, due to the need for only one component per unit regardless of capacity. In other words, there are certain fixed production costs that are present no matter the size of the boiler and only the variable costs increase with boiler size. For instance, a larger boiler would utilize the same controls and wiring harness as a smaller boiler, the cost of which would remain fixed regardless of the input capacity. DOE did find one relevant example, a higher-capacity premix burner, which may be purchased at a higher cost due to a lack of economy of scale. However, DOE believes that the potential increase in price of this purchase part would be offset by the many instances in which the production costs remain fixed regardless of capacity.

DOE notes that shipping costs are considered a sales expense and not a production cost. As discussed in section IV.C.2.e, when translating MPCs to MSPs, DOE applies a manufacturer mark-up to the MPC. This mark-up, based on an analysis of manufacturer SEC 10–K reports, includes outbound freight costs. Therefore, any increase in MPC would account for larger shipping costs via a higher MSP.

''Standby mode'' and ''off mode'' power consumption are defined in the DOE test procedure for residential furnaces and boilers. DOE defines ''standby mode'' as ''any mode in which the furnace or boiler is connected to a mains power source and offers one or more of the following space heating functions that may persist: a.) To facilitate the activation of other modes (including activation or deactivation of active mode) by remote switch (including thermostat or remote control), internal or external sensors, or timer; b.) Continuous functions, including information or status displays or sensor based functions.'' 10 CFR part 430, subpart B, appendix N, section 2.12. ''Off mode'' is defined as ''a mode in which the furnace or boiler is connected to a mains power source and is not providing any active mode or standby mode function, and where the mode may persist for an indefinite time.

The existence of an off switch in off position (a disconnected circuit) is included within the classification of off mode.'' 10 CFR part 430, subpart B, appendix N, section 2.9. Finally, an ''off switch'' is defined as ''the switch on the furnace or boiler that, when activated, results in a measurable change in energy consumption between the standby and off modes.'' 10 CFR part 430, subpart B, appendix N, section 2.10.

Through review of product literature and discussions with manufacturers, DOE has found that boilers typically do not have an off switch. Manufacturers stated that if a switch is included with a product, it is primarily used as a service/repair switch, not for turning off the product during the off season. However, these switches could possibly be used as off switches by the consumer. In cases where no off switch is present, no separate measurement for off mode is taken during testing, and the DOE test procedure sets off mode power equal to standby mode power ($P_{W,OFF} = P_{W,SB}$). In the case where an off switch is present, a measurement for off mode is required. 10 CFR part 430, subpart B, appendix N, section 8.11.2. Because DOE's review of product literature and discussions with manufacturers revealed that most boilers do not have seasonal off switches, DOE assumed that the standby mode and the off mode power consumption are equal for its analysis.

To determine the baseline standby mode and off mode power consumption, DOE identified baseline components as those that consume the most electricity during the operation of those modes. Since it would not be practical for DOE to test every boiler on the market to determine the baseline and since manufacturers do not currently report standby mode and off mode energy consumption, DOE ''assembled'' the most consumptive baseline components from the models tested to model the electrical system of a boiler with the expected maximum system standby mode and off mode power consumption observed during testing of boilers and similar equipment. The baseline standby mode and off mode power consumption levels used in the NOPR and final rule analysis are presented in Table IV.3.

TABLE IV.3—BASELINE STANDBY MODE AND OFF MODE POWER CONSUMPTION

Component	Standby mode and off mode power consumption (watts)					
	Gas-fired hot water	Oil-fired hot water	Gas-fired steam	Oil-fired steam	Electric hot water	Electric steam
Transformer	4	4	4	4	4	4
ECM Burner Motor	1	N/A	N/A	N/A	N/A	N/A
Controls	2.5	2.5	2.5	2.5	2.5	2.5
Display	4	4	4	4	4	4
Oil Burner	N/A	3	N/A	3	N/A	N/A
Total (watts)	11.5	13.5	10.5	13.5	10.5	10.5

In response to the NOPR standby mode and off mode analysis, Lochinvar suggested DOE should not regulate standby electricity consumption, because the standby electrical power consumption releases useful heat inside the home. Lochinvar highlighted that DOE's test method for residential boilers affirms its position by assigning a jacket loss factor of 0 for ''boilers intended to be installed indoors.'' However, Lochinvar agreed that DOE should regulate off mode power consumption. Lochinvar also agreed with DOE's assumption that most consumers do not turn off power to their boilers seasonally and suggested that DOE should invest effort into promoting turning off power to the boiler when there is no need for heating. Lochinvar stated that baseline power consumption predicted by DOE is reasonable, but that the assumption that the standby mode energy consumption is the same as the off mode energy consumption is erroneous. (Lochinvar, No. 63 at pp. 1–4)

In response to the suggestion that DOE not regulate standby mode, DOE notes that it is statutorily required to consider both standby mode and off mode electrical power consumption under EPCA at 42 U.S.C. 6295(gg)(3). As outlined in section III.B, the DOE test procedure references two industry standards, ASHRAE 103–1993, which is used to determine the heating efficiency of a residential boiler, and IEC 62301, which is used to determine the standby mode and off mode energy consumption of a residential boiler. As noted by Lochinvar, ASHRAE 103 considers the jacket losses as usable heat for boilers intended to be installed indoors. However, the power consumption as measured by IEC Standard 62301 is a consumption metric and not an efficiency metric and is considered separately from the AFUE. The DOE test procedure for standby mode does not treat those boilers intended to be installed indoors any differently than those intended to be installed outdoors or in other unconditioned spaces, where the heat produced by the standby mode use would be a loss. While the majority of residential boilers may be installed indoors (as is assumed by the DOE test procedure), there are boilers available on the market that are designed for installation in unconditioned spaces or outdoors where any heat released by standby electrical power consumption would not be useful. Therefore, DOE has concluded it is appropriate to regulate the standby mode power consumption.

In response to the assertion that standby mode and off mode consumption are not equal, DOE agrees that standby mode energy consumption and off mode energy consumption are not equal in all cases (*i.e.,* if there is an off switch present). However, DOE notes that in cases where no off switch is present (which based on DOE's review of the market and information obtained during manufacturer interviews is the most common situation), off mode use is equal to the standby mode use when tested according to DOE's test method. 10 CFR part 430, subpart B, appendix N, section 8.11.2. DOE notes that Lochinvar agreed with DOE's assumption that most consumers do not turn off power to their boilers seasonally. As noted, DOE has determined that an off switch is generally not present, so DOE has maintained its assumption that standby mode and off mode are equivalent under the DOE test method.

In response to the methodology presented in the NOPR for determining the efficiency levels by focusing on energy consumptive components, AHRI stated the component analysis methodology did not include any analysis of the standby mode and off mode energy consumptions of current boiler models. AHRI stated that information from their members indicated that some boiler models have standby mode and off mode energy consumptions significantly above the baseline values used in the analysis. AHRI added that depending on how they are counted, accessories can influence the final standby power consumption which might impact the decisions about which accessories are provided with the boiler. For example, AHRI commented that outdoor temperature reset controls, which are used by many equipment manufacturers to comply with DOE design requirements, were not included in the baseline model analysis. AHRI recommended that DOE recalibrate this analysis with a higher baseline reflective of current models. (AHRI, No. 64 at p. 14) Burnham provided standby mode and off mode power measurements in terms of Volt-Amps (VA),[23] rather than watts, for each representative product class and indicated that, with the possible exception of the gas-fired steam product class, DOE's baseline models for standby/off mode power overstate current consumption significantly. (Burnham, No. 60 at p. 21) Burnham also stated that the availability of data from actual control systems, not a hypothetical construct, should be used to determine baselines, and suggested that DOE should expend the time and resources needed to obtain a reasonable amount of data upon which to form a conclusion before proceeding with this rulemaking. (Burnham, No. 60 at p. 21)

In response, DOE tested the standby consumption of several boilers, including those with outdoor reset controls. However, DOE chose to use a component analysis approach in the standby mode and off mode analysis in order to take into account the energy use of all possible accessories so as to prevent any possible limitation on the use of such accessories. For each product class, the baseline selected was greater than any model tested by DOE. During manufacturer interviews, no manufacturer indicated that any of their models exceeded the baseline selected by DOE for each product class. In the absence of any data showing that the standby mode and off mode energy consumption is higher than the DOE baseline levels, DOE has maintained the same levels for the final rule. DOE believes that this approach benefits manufacturers by allowing for flexibility of designs and ensuring that the standard will be set at a reasonable level that does not restrict the inclusion of technologies that could improve energy efficiency or provide consumer utility. DOE notes that AHRI's comment regarding higher baselines contradicts Burnham's comment which indicate that the standby mode and off mode baseline levels are high for most product classes. Further, Lochinvar's comment indicated that the baseline power consumption predicted by DOE is reasonable.

Regarding the standby mode data provided by Burnham, DOE notes that the DOE test procedure measures standby and off mode electricity consumption in terms of real power (watts) rather than apparent power (VA). The data provided by Burnham cannot be incorporated into the standby mode and off mode analysis without the power factor of the units tested. DOE notes that there are hundreds of residential boiler models on the market with varying accessories, control systems, and power supplies. The assumptions made in the component analysis used for the determination for the baseline levels are rooted upon actual test data. DOE used a component-focused analysis that considered the most energy consumptive individual components in order to prevent setting a standard which could limit manufacturers' ability to utilize accessories which may consume power in standby mode, but reduce active mode energy use, or provide other consumer utility.

b. Other Energy Efficiency Levels

Table IV.4 through Table IV.7 show the efficiency levels DOE selected for the final rule analysis of amended AFUE standards, along with a description of the typical technological change at each level. These efficiency levels are the same as were presented in the NOPR, and following the same rationale, they are based upon the most common efficiency levels found on the market or a significant technology (*e.g.,* condensing technology). In addition, DOE is statutorily required to consider the maximum technologically feasible efficiency level (''max-tech'').

TABLE IV.4—AFUE EFFICIENCY LEVELS FOR GAS-FIRED HOT WATER BOILERS

Efficiency level	AFUE (%)	Technology options
0–Baseline	82	Baseline.
1	83	EL0 + Increased Heat Exchanger (HX) Area, Baffles.
2	84	EL1 + Increased HX Area.
3	85	EL2 + Increased HX Area.
4	90	Condensing HX.
5	92	EL4 + Improved HX.
6–Max-Tech	96	EL5 + Improved HX.

TABLE IV.5—AFUE EFFICIENCY LEVELS FOR GAS-FIRED STEAM BOILERS

Efficiency level	AFUE (%)	Technology options
0–Baseline	80	Baseline.
1	82	EL0 + Increased HX Area.
2–Max-Tech	83	EL1+ Increased HX Area.

[23] The voltage and current of an AC circuit constantly change over time. Due to this, the following terms are used to describe energy flow in a system. Real power performs work and is measured in Watts (W). Reactive power does not perform work and is measured in VA reactive (VAr). Complex power is the vector sum of real and reactive power measurement in volt amps (VA). Apparent power is the magnitude of the complex power measured in volt amps (VA).

TABLE IV.6—AFUE EFFICIENCY LEVELS FOR OIL-FIRED HOT WATER BOILERS

Efficiency level	AFUE (%)	Technology options
0–Baseline	84	Baseline.
1	85	EL0 + Increased HX Area.
2	86	EL1 + Increased HX Area.
3–Max-Tech	91	EL2 + Improved HX, Baffles, and Secondary Condensing HX.

TABLE IV.7—AFUE EFFICIENCY LEVELS FOR OIL-FIRED STEAM BOILERS

Efficiency level	AFUE (%)	Technology options
0–Baseline	82	Baseline.
1	84	EL0 + Increased HX Area.
2	85	EL1 + Increased HX Area.
3–Max-Tech	86	EL2 + Improved HX.

Several stakeholders raised concerns in response to the consideration of efficiency levels 1 through 3 selected for the gas-fired hot water boiler product class in the NOPR analysis. (Burnham, No. 60 at p. 17; Lochinvar, No. 63 at p. 2; AGA, No. 54 at p. 11) Lochinvar and Burnham expressed concern that the designs necessary to reach these efficiency levels increase the cost of the boiler, as well as the risk of condensation and carbon monoxide issues occurring. Lochinvar and Burnham argued that more frequent and prolonged exposure to condensate as a result of these designs, as well as the automatic means requirement, will increase the potential of condensation-related problems, such as nuisance faults, blocked heat exchangers, and corroding vents. Lochinvar and Burnham further argued that the corrosion of conventional venting by condensate may lead to the spilling of carbon monoxide into occupied spaces, thereby resulting in safety concerns. (Lochinvar, No. 63 at p. 2; Burnham No. 60 at p. 4) Lochinvar also stated that the sizing, installation, and operating conditions also influence the potential for condensation. (Lochinvar, No. 63 at p. 3)

The Department recognizes that certain efficiency levels could pose health or safety concerns under certain conditions if they are not installed properly in accordance with manufacturer specifications. However, these concerns can be resolved with proper product installations and venting system design. This is evidenced by the significant shipments of products that are currently commercially available at these efficiency levels, as well as the lack of restrictions on the installation location of these units in installation manuals. In addition, DOE notes that products achieving these efficiency levels have been on the market since at least 2002, which demonstrates their reliability, safety, and consumer acceptance. Given the significant product availability and the amount of time products at these efficiency levels have been available on the market, DOE continues to believe that products at these efficiency levels are safe and reliable when installed correctly. Therefore, DOE has maintained the efficiency levels above 82 percent and below 90 percent in its final rule analysis. Discussion related to the costs associated with the installation of venting systems to prevent condensation and corrosion issues are outlined in section IV.F.2 of this final rule.

In addition, DOE considered whether changes to the residential furnaces and boilers test procedure adopted by the January 2016 test procedure final rule would necessitate changes to the AFUE levels being analyzed. The primary changes adopted in the test procedure are listed in section III.B. Adopting these provisions was assessed as having no impact on the AFUE for residential boilers. (See EERE–2012–BT–TP–0024) In response to the March 2015 NOPR, several stakeholders submitted comments suggesting that the proposed changes outlined in the March 2015 TP NOPR would impact the measured AFUE of products and ultimately impact the standards rulemaking. As described in section III.F, the January 2016 TP FR did not adopt any provisions impacting AFUE. Consequently, DOE used the same AFUE efficiency levels in the final rule analysis as were used in the NOPR analysis.

Table IV.8 through Table IV.13 show the efficiency levels DOE selected for the final rule analysis of standby mode and off mode standards, along with a description of the typical technological change at each level. DOE maintained the efficiency levels used in the NOPR stage of the analysis.

TABLE IV.8—STANDBY MODE AND OFF MODE EFFICIENCY LEVELS FOR GAS-FIRED HOT WATER BOILERS

Efficiency level	Standby mode and off mode power consumption (W)	Technology options
0–Baseline	11.5	Linear Power Supply.*
1	10.0	Linear Power Supply with Low-Loss Transformer (LLTX).
2	9.7	Switching Mode Power Supply.**
3–Max-Tech	9.0	Switching Mode Power Supply with LLTX.

* A linear power supply regulates voltage with a series element.

** A switching mode power supply regulates voltage with power handling electronics.

TABLE IV.9—STANDBY MODE AND OFF MODE EFFICIENCY LEVELS FOR GAS-FIRED STEAM BOILERS

Efficiency level	Standby mode and off mode power consumption (W)	Technology options
0–Baseline	10.5	Linear Power Supply.
1	9.0	Linear Power Supply with LLTX.
2	8.7	Switching Mode Power Supply.
3–Max-Tech	8.0	Switching Mode Power Supply with LLTX.

TABLE IV.10—STANDBY MODE AND OFF MODE EFFICIENCY LEVELS FOR OIL-FIRED HOT WATER BOILERS

Efficiency level	Standby mode and off mode power consumption (W)	Technology options
0–Baseline	13.5	Linear Power Supply.
1	12.0	Linear Power Supply with LLTX.
2	11.7	Switching Mode Power Supply.
3–Max-Tech	11.0	Switching Mode Power Supply with LLTX.

TABLE IV.11—STANDBY MODE AND OFF MODE EFFICIENCY LEVELS FOR OIL-FIRED STEAM BOILERS

Efficiency level	Standby mode and off mode power consumption (W)	Technology options
0–Baseline	13.5	Linear Power Supply.
1	12.0	Linear Power Supply with LLTX.
2	11.7	Switching Mode Power Supply.
3–Max-Tech	11.0	Switching Mode Power Supply with LLTX.

TABLE IV.12—STANDBY MODE AND OFF MODE EFFICIENCY LEVELS FOR ELECTRIC HOT WATER BOILERS

Efficiency level	Standby mode and off mode power consumption (W)	Technology options
0–Baseline	10.5	Linear Power Supply.
1	9.0	Linear Power Supply with LLTX.
2	8.7	Switching Mode Power Supply.
3–Max-Tech	8.0	Switching Mode Power Supply with LLTX.

TABLE IV.13—STANDBY MODE AND OFF MODE EFFICIENCY LEVELS FOR ELECTRIC STEAM BOILERS

Efficiency level	Standby mode and off mode power consumption (W)	Technology options
0–Baseline	10.5	Linear Power Supply.
1	9.0	Linear Power Supply with LLTX.
2	8.7	Switching Mode Power Supply.
3–Max-Tech	8.0	Switching Mode Power Supply with LLTX.

2. Cost-Assessment Methodology

At the start of the engineering analysis, DOE identified the energy efficiency levels associated with residential boilers on the market using data gathered in the market assessment. DOE also identified the technologies and features that are typically incorporated into products at the baseline level and at the various energy efficiency levels analyzed above the baseline. Next, DOE selected products for the physical teardown analysis having characteristics of typical products on the market at the representative input capacity. DOE gathered information by performing a physical teardown analysis (see section

IV.C.2.a) to create detailed BOMs, which included all components and processes used to manufacture the products. DOE used the BOMs from the teardowns as an input to a cost model, which was then used to calculate the MPC for products at various efficiency levels spanning the full range of efficiencies from the baseline to the max-tech. DOE reexamined and revised its cost assessment performed for the NOPR analysis based on response to comments received on the NOPR analysis.

During the development of the engineering analysis for the NOPR, DOE held interviews with manufacturers to gain insight into the residential boiler industry, and to request feedback on the engineering analysis and assumptions that DOE used. DOE used the information gathered from these interviews, along with the information obtained through the teardown analysis and public comments, to refine the assumptions and data in the cost model. Next, DOE derived manufacturer markups using publicly-available residential boiler industry financial data in conjunction with manufacturers' feedback. The markups were used to convert the MPCs into MSPs. Further information on comments received and the analytical methodology is presented in the subsections below. For additional detail, see chapter 5 of the final rule TSD.

a. Teardown Analysis

To assemble BOMs and to calculate the manufacturing costs for the different components in residential boilers, 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 referred to 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 ''virtual teardown,'' which examines published manufacturer catalogs and supplementary component data to estimate the major physical differences between a product that was physically disassembled and a similar product that was not. For supplementary virtual teardowns, DOE gathered product data such as dimensions, weight, and design features from publicly-available information, such as manufacturer catalogs. The initial teardown analysis for the NODA included 6 physical and 5 virtual teardowns of residential boilers. The NOPR teardown analysis included 16 physical and 4 virtual teardowns of residential boilers. DOE performed no further teardowns in the final rule analysis, but updated the costs data inputs based on the most recent materials and purchased part price information available.

DOE selected the majority of the physical teardown units in the gas hot water product class because it has the largest number of shipments. DOE conducted physical teardowns of twelve gas hot water boilers, five of which were non-condensing cast iron boilers, two of which were non-condensing copper boilers, and the remaining five of which were condensing boilers. DOE performed an additional two virtual teardowns of gas hot water boilers.

DOE also performed physical teardowns on two gas-fired steam boilers, as well as two oil-fired hot water boilers. DOE conducted one virtual teardown of an oil-fired steam boiler, as well as a virtual teardown of an oil-fired hot water boiler.

The teardown analysis allowed DOE to identify the technologies that manufacturers typically incorporate into their products, 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 virtual 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 as inputs to the cost model to calculate the MPC for each product that was torn down. The MPCs resulting from the teardowns were then used to develop an industry average MPC for each product class analyzed.

More information regarding details on the teardown analysis can be found in chapter 5 of the final rule TSD.

b. Cost Model

The cost model is a spreadsheet that converts the materials and components in the BOMs into dollar values based on the price of materials, average labor rates associated with manufacturing and assembling, and the cost of overhead and depreciation, as determined based on manufacturer interviews. To convert the information in the BOMs to dollar values, DOE collected information on labor rates, tooling costs, raw material prices, and other factors. For purchased parts, the cost model estimates the purchase price based on volume-variable price quotations and detailed discussions with manufacturers and component suppliers. For fabricated parts, the prices of raw metal materials [24] (*e.g.,* tube, sheet metal) are estimated on the basis of 5-year averages (from 2009 to 2014). The cost of transforming the intermediate materials into finished parts is estimated based on current industry pricing.[25]

c. Manufacturing Production Costs

Once the cost estimates for all the components in each teardown unit were finalized, DOE totaled the cost of materials, labor, and direct overhead used to manufacture a product in order to calculate the manufacturer production cost. The total cost of the product was broken down into two main costs: (1) The full manufacturer production cost, referred to as MPC; and (2) the non-production cost, which includes selling, general, and administration (SG&A) expenses; the cost of research and development; and interest from borrowing for operations or capital expenditures. DOE estimated the MPC at each efficiency level considered for each product class, from the baseline through the max-tech. After incorporating all of the assumptions into the cost model, DOE calculated the percentages attributable to each element of total production cost (*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 manufacturer impact analysis (MIA) (see section IV.J).

DOE considered the draft type (*i.e.,* natural draft or fan-assisted draft) and whether the model would have fan-assisted draft at a given efficiency level. Some boilers utilize natural draft, in which the natural buoyancy of the combustion gases is sufficient to vent those gases. Other boilers employ fan-assisted draft to help vent the products of combustion. As product efficiency increases, more heat is extracted from the flue gases, thereby resulting in less natural buoyancy that can be used to vent the flue gases. Through market review, DOE determined that the use of fan-assisted draft was based not only on efficiency, but also on installation considerations that impact draft.

[24] American Metals Market (Available at: *http://www.amm.com/*)(Last accessed January, 2015).

[25] U.S. Department of Labor, Bureau of Labor Statistics, Producer Price Indexes (Available at: *http://www.bls.gov/ppi/*) (Last accessed January, 2015).

Therefore, DOE estimated the additional cost of adding an inducer fan to a product, and the costs were added to a certain percentage of boilers at each efficiency level in the LCC analysis (see section IV.F.2 of this final rule).

In response to the MPC's presented in the NOPR, Weil-McLain stated that increasing efficiencies would require not just larger heat exchangers, but also different burners and flue dampers, in addition to the mechanical venting inducer necessary for fan-assisted draft. Weil-McLain added that non-product cost increases would be created by additional electric power consumption required to run the inducer or blower, new electric service installation in some instances, new venting and/or chimney lining, re-piping, and higher maintenance costs due to inducers/blowers and positive pressure vent systems. (Weil-McLain, No. 55 at p. 3)

Similarly, AHRI stated that DOE mischaracterized the design changes required to achieve the proposed minimum standards, and, therefore, the resulting cost to manufacturers is underestimated. Specifically, AHRI stated that DOE assumed that the only design change necessary to achieve the proposed revised minimum AFUE levels is to increase the heat exchanger area. AHRI argued that this analysis is incomplete because it fails to recognize the additional changes. AHRI suggested that in some cases models may become bigger to accommodate the larger heat exchanger. In those cases, a larger model will require more material for the jacket and other design modifications. (AHRI, No. 64 at p. 12) Burnham stated that DOE did not include the cost of the system pump that manufacturers send along with the residential boiler. (Burnham, No. 60 at p. 24)

In response to the commenters' statements, DOE notes that the intent of listing the technology option corresponding to each efficiency level was to give stakeholders information on the specific design change that has been observed as the primary driver of improved efficiency; it was not intended to convey every component that will change from one efficiency level to the next. The increase in heat exchanger surface area was the primary technological driver in improving efficiency for many of the efficiency levels, and is, therefore, the technology option listed in those cases. The ancillary costs associated with increasing efficiency were included in the development of the MPC's at all efficiency levels, including those that primarily rely on increases in heat exchanger surface area noted by AHRI and Weil-McLain. When DOE performed the physical teardown analysis, it observed and accounted for any differences in other ancillary components at higher efficiency levels. DOE notes that the cost of the system pump is included in the manufacturer production costs for hot water boilers. The non-product costs highlighted by Weil-McLain related to installation and energy costs are captured in the installation and maintenance cost of the LCC analysis, described in section IV.F of this final rule.

Burnham suggested there would be a significant cost increase for oil-fired and steam boilers as a result of a reduction in the production of cast iron gas-fired hot water boilers due to standards. Burnham stated that the fixed cost associated with foundry operation would be spread over a smaller number of castings. (Burnham, No. 60 at p. 17)

DOE notes that the standard level set for gas-fired hot water boilers still allows for the use of cast iron heat exchanger designs. DOE does not anticipate a reduction in shipments for this product class as a result of new standards. Therefore, DOE does not anticipate an increase cost for oil-fired and steam product classes.

In the final rule analysis, DOE revised the cost model assumptions it used for the NOPR analysis based on updated pricing information (for raw materials and purchased parts). These changes resulted in refined MPCs and production cost percentages. Table IV.14 through Table IV.17 present DOE's estimates of the MPCs by AFUE efficiency level for this rulemaking.

TABLE IV.14—MANUFACTURING COST FOR GAS-FIRED HOT WATER BOILERS

Efficiency level	Efficiency level (AFUE) (%)	MPC * ($)	Incremental cost ($)
Baseline	82	627	
EL1	83	635	8
EL2	84	642	15
EL3	85	677	50
EL4	90	1,010	383
EL5	92	1,180	553
EL6	96	1,516	889

* Non-condensing boilers (< 90 percent AFUE) are available with or without an inducer. The costs shown reflect the MPC for a boiler without an inducer.

TABLE IV.15—MANUFACTURING COST FOR GAS-FIRED STEAM BOILERS

Efficiency level	Efficiency level (AFUE) (%)	MPC * ($)	Incremental cost ($)
Baseline	80	778	
EL1	82	793	15
EL2	83	925	147

* Non-condensing boilers (< 90 percent AFUE) are available with or without an inducer. The costs shown reflect the MPC for a boiler without an inducer.

TABLE IV.16—MANUFACTURING COST FOR OIL-FIRED HOT WATER BOILERS

Efficiency level	Efficiency level (AFUE) (%)	MPC * ($)	Incremental cost ($)
Baseline	84	1,228	
EL1	85	1,302	75
EL2	86	1,377	149
EL3	91	2,314	1,087

* Non-condensing boilers (< 90 percent AFUE) are available with or without an inducer. The costs shown reflect the MPC for a boiler without an inducer.

TABLE IV.17—MANUFACTURING COST FOR OIL-FIRED STEAM BOILERS

Efficiency level	Efficiency level (AFUE) (%)	MPC * ($)	Incremental cost ($)
Baseline	82	1,252	
EL1	84	1,401	149
EL2	85	1,475	224
EL3	86	1,625	373

* Non-condensing boilers (< 90 percent AFUE) are available with or without an inducer. The costs shown reflect the MPC for a boiler without an inducer.

Table IV.18 through Table IV.23 present DOE's estimates of the MPCs at each standby mode and off mode efficiency level for this rulemaking.

TABLE IV.18—MANUFACTURING COST FOR GAS-FIRED HOT WATER BOILERS STANDBY MODE AND OFF MODE

Efficiency level	Standby mode and off mode power consumption (W)	MPC ($)	Incremental cost ($)
Baseline	11.5	8.55	
EL1	10.0	10.40	1.85
EL2	9.7	18.53	9.98
EL3	9.0	19.02	10.47

TABLE IV.19—MANUFACTURING COST FOR GAS-FIRED STEAM BOILERS STANDBY MODE AND OFF MODE

Efficiency level	Standby mode and off mode power consumption (W)	MPC ($)	Incremental cost ($)
Baseline	10.5	8.55	
EL1	9.0	10.40	1.85
EL2	8.7	18.53	9.98
EL3	8.0	19.02	10.47

TABLE IV.20—MANUFACTURING COST FOR OIL-FIRED HOT WATER BOILERS STANDBY MODE AND OFF MODE

Efficiency level	Standby mode and off mode power consumption (W)	MPC ($)	Incremental cost ($)
Baseline	13.5	8.55	
EL1	12.0	10.40	1.85
EL2	11.7	18.53	9.98
EL3	11.0	19.02	10.47

TABLE IV.21—MANUFACTURING COST FOR OIL-FIRED STEAM BOILERS STANDBY MODE AND OFF MODE

Efficiency level	Standby mode and off mode power consumption (W)	MPC ($)	Incremental cost ($)
Baseline	13.5	8.55	
EL1	12.0	10.40	1.85
EL2	11.7	18.53	9.98
EL3	11.0	19.02	10.47

TABLE IV.22—MANUFACTURING COST FOR ELECTRIC HOT WATER BOILERS STANDBY MODE AND OFF MODE

Efficiency level	Standby mode and off mode power consumption (W)	MPC ($)	Incremental cost ($)
Baseline	10.5	8.55	
EL1	9.0	10.40	1.85
EL2	8.7	18.53	9.98
EL3	8.0	19.02	10.47

TABLE IV.23—MANUFACTURING COST FOR ELECTRIC STEAM BOILERS STANDBY MODE AND OFF MODE

Efficiency level	Standby mode and off mode power consumption (W)	MPC ($)	Incremental cost ($)
Baseline	10.5	8.55	
EL1	9.0	10.40	1.85
EL2	8.7	18.53	9.98
EL3	8.0	19.02	10.47

Chapter 5 of the final rule TSD presents more information regarding the development of DOE's estimates of the MPCs for this rulemaking.

d. Cost-Efficiency Relationship

The result of the engineering analysis is a cost-efficiency relationship. DOE created cost-efficiency curves representing the cost-efficiency relationship for each product class that it examined. To develop the cost-efficiency relationships for residential boilers, DOE examined the cost differential to move from one efficiency level to the next for each manufacturer. DOE used the results of teardowns on a market-share-weighted average basis to determine the industry average cost increase to move from one efficiency level to the next. Additional details on how DOE developed the cost-efficiency relationships and related results are available in chapter 5 of the final rule TSD, which also presents these cost-efficiency curves in the form of energy efficiency versus MPC.

The results indicate that cost-efficiency relationships are nonlinear. In other words, as efficiency increases, manufacturing becomes more costly. A large cost increase is evident between non-condensing and condensing efficiency levels due to the requirement for a heat exchanger that can withstand corrosive condensate.

e. 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 generally 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 typically introduce design changes to their product lines that increase manufacturer production costs. Depending on the competitive environment for these particular products, some or all of the increased production costs may be passed from manufacturers to retailers and eventually to consumers in the form of higher purchase prices. As production costs increase, manufacturers typically incur additional overhead. For a profitable business, the MSP should be high enough to recover the full cost of the product (*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 expenditures) to 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 [26] submitted to the U.S. Securities and Exchange Commission (SEC) by the three publicly-owned residential boiler companies. The financial figures necessary for calculating the manufacturer markup are net sales, costs of sales, and gross profit. For boilers, DOE averaged the financial figures spanning the years 2008 to 2012 in order to calculate the markups. DOE used this approach because amended

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

standards may transform high-efficiency products (which currently are considered premium products) into typical products. DOE acknowledges that there are numerous manufacturers of residential boilers 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 residential boiler portion of their business and can also include financial information from other product sectors, whose margins could be quite different from the residential boiler industries. DOE discussed the manufacturer markup with manufacturers during interviews, and used the feedback to validate the markup calculated through review of SEC 10–K reports. DOE received no comments regarding the manufacturer markup used in the NODA and NOPR analysis. See chapter 5 of the final rule TSD for more details about the manufacturer markup calculation.

f. Manufacturer Interviews

Throughout the rulemaking process, DOE has sought feedback and insight from interested parties that would improve the information used in its analyses. DOE interviewed manufacturers as a part of the manufacturer impact analysis (see section IV.J.3). During the interviews, DOE sought feedback on all aspects of its analyses for residential boilers. For the engineering analysis, DOE discussed the analytical inputs, assumptions, and estimates, and cost-efficiency curves with residential boiler manufacturers. DOE considered all the information manufacturers provided when refining its analytical inputs and assumptions. However, DOE incorporated equipment and manufacturing process figures into the analysis as averages in order to avoid disclosing sensitive information about individual manufacturers' products or manufacturing processes. More details about the manufacturer interviews are contained in chapter 12 of the final rule TSD.

D. Markups Analysis

DOE uses appropriate markups (*e.g.,* manufacturer markups, retailer markups, distributor markups, contractor markups) and sales taxes to convert the manufacturer selling price (MSP) estimates from the engineering analysis to 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 product markups at each step in the distribution chain. The markups are multipliers that represent increases above the MSP for residential boilers. The incremental markup relates the change in the manufacturer sales price of higher-efficiency models (the incremental cost increase) to the change in the consumer price. Before developing markups, DOE defines key market participants and identifies distribution channels.

Commenting on the NOPR, AHRI stated that based on preliminary survey feedback, contractors only apply a single markup regardless of the product efficiency. (AHRI, Public Meeting Transcript, No. 50 at pp. 71–72) Burnham further stated that AHRI's comments demonstrate that DOE's use of ''incremental'' markups through the distribution channel has no foundation either in theory or actual practice. Burnham stated that DOE must eliminate the use of incremental markups before it promulgates a new rule for boilers. (Burnham, No. 60 at pp. 19–20)

DOE believes that AHRI's comments on the NOPR referred to more extensive comments that it provided in response to the 2014 NOPR for small, large, and very large commercial package air conditioning and heating equipment. (EERE–2013–BT–STD–0007) In these comments, AHRI included a report that laid out three main arguments: (1) The incremental markup approach relies on an assumption of perfect competition, which is an outdated model of the economy; (2) relatively constant percent gross margins observed in aggregated HVAC industry data imply the use of fixed-percent markups over time; and (3) interview responses from wholesalers and contractors are consistent with the use of fixed-percent markups. ([Docket No. EERE–2013–BT–STD–0007], AHRI, No. 68 at p. 29)

DOE responds to these points as follows:

(1) DOE's incremental markup approach is based on the widely accepted economic view that prices closely reflect marginal costs in competitive markets and in those with a limited degree of concentration. Economic theory permits that an incremental cost can have a markup on it that is different from the markup on the baseline product, and DOE's incremental markup approach follows this assumption. AHRI does not provide sufficient proof that such theory should be abandoned in the case of the HVAC industry.

(2) In examining the relatively constant HVAC percent margin trend and its underlying prices, DOE found that the average inflation-adjusted prices of HVAC products are relatively fixed during this period as well. This set of historical data has no bearing on firm markup behavior under product price increases, such as DOE projects would occur when higher-efficiency products are introduced. If prices are relatively constant, the incremental markup approach will arrive at the same price prediction as applying fixed-percent margin; hence, the historically constant percent margins do not necessarily imply a constant percent margin in the future, especially in the case of increased input prices. DOE evaluated time series margin and price data from three industries that experienced rapidly changing input prices—the LCD television retail market, the U.S. oil and gasoline market, and the U.S. housing market. The results indicate that dollar margins vary across different markets to reflect changes in input price, but the percent margins do not remain fixed over time in any of these industries. Appendix 6B in the final rule TSD describes DOE's findings.

(3) It is not clear whether the interview responses received by AHRI reflect an accurate understanding of DOE's incremental markup approach. In contrast to the characterization of those responses by AHRI, an in-depth interview with an HVAC consultant conducted by DOE indicates that while HVAC contractors aim to maintain fixed percent markups, market pressures force them to reevaluate and adjust markups over time to stay competitive.

DOE concludes that there is not sufficient evidence to support the application of fixed percent markups to the cost increment on efficient equipment. Further discussion is found in section 6.4 and appendix 6B of the final rule TSD. In spite of their efforts to do so, firms in this market generally cannot maintain fixed percent margins in the long run under changing cost conditions. DOE's incremental markup approach allows the part of the cost that is thought to be affected by the standard to scale with the change in manufacturer price.

For the NOPR, DOE characterized three distribution channels to describe how residential boiler products pass from the manufacturer to residential and commercial consumers: (1) Replacement market; (2) new construction, and (3) national accounts.[27] 80 FR 17222,

[27] The national accounts channel is an exception to the usual distribution channel that is only applicable to those residential boilers installed in the small to mid-size commercial buildings where the on-site contractor staff purchase equipment directly from the wholesalers at lower prices due

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17249–50 (March 31, 2015). The replacement market distribution channel is characterized as follows:

Manufacturer → Wholesaler → Mechanical contractor → Consumer

The new construction distribution channel is characterized as follows:

Manufacturer → Wholesaler → Mechanical contractor → General contractor → Consumer

In the third distribution channel, the manufacturer sells the product to a wholesaler and then to the commercial consumer through a national account:

Manufacturer → Wholesaler → Consumer (National Account)

DOE did not receive any comments on the distribution channels, and used the same distribution channels for the final rule.

To develop markups for the parties involved in the distribution of the product, for the NOPR, DOE utilized several sources, including: (1) The Heating, Air-Conditioning & Refrigeration Distributors International (HARDI) 2012 Profit Report [28] to develop wholesaler markups; (2) U.S. Census Bureau's 2007 Economic Census data [29] for the commercial and institutional building construction industry to develop mechanical and general contractor markups. In addition, DOE used the 2005 Air Conditioning Contractors of America's (ACCA) Financial Analysis for the Heating, Ventilation, Air-conditioning, and Refrigeration (HVACR) Contracting Industry Report [30] to disaggregate the mechanical contractor markups into replacement and new construction markets.

Commenting on the NOPR, ACCA expressed its concern that DOE used ACCA's 2005 Financial Analysis for the HVACR Contracting Industry Report for its markup analysis because this report is more than a decade old and not a relevant resource. (ACCA, No. 65 at p. 2) In response, DOE only uses the ACCA 2005 Report to derive the ratios of the markup in new construction applications and in replacement applications to the markup for all installations. ACCA's 2005 Financial Analysis is the only public source available that disaggregates HVAC contracting industry into replacement and new construction markets. DOE acknowledges that many financial conditions of the HVAC contracting industry have changed since 2005, but DOE believes that markups would tend to fluctuate in a similar manner for both new construction and replacement applications, and, thus, the ratios for 2005 mentioned above are not likely to change significantly over time. Therefore, DOE continued to use ACCA's 2005 Financial Analysis in the markup analysis for the final rule for this limited purpose.

In addition to the markups, DOE derived State and local taxes from data provided by the Sales Tax Clearinghouse.[31] These data represent weighted-average taxes that include county and city rates. DOE derived shipment-weighted-average tax values for each region considered in the analysis.

Chapter 6 of the final rule TSD provides further detail on the estimation of markups.

E. Energy Use Analysis

The energy use analysis determines the annual energy consumption of residential boilers at different efficiencies in representative U.S. single-family homes, multi-family residences, and commercial buildings, and assesses the energy savings potential of increased boiler efficiency. DOE estimated the annual energy consumption of residential boilers at specified energy efficiency levels across a range of climate zones, building characteristics, and heating applications. The annual energy consumption includes the natural gas, liquid petroleum gas (LPG), oil, and/or electricity use by the boiler for space and water heating. The annual energy consumption of residential boilers is used in subsequent analyses, including the LCC and PBP analysis and the national impacts analysis.

1. Building Sample

For the NOPR, for the residential sector, DOE used the Energy Information Administration's (EIA) 2009 Residential Energy Consumption Survey (RECS 2009) to establish a sample of households using residential boilers for each boiler product class.[32] The RECS data provide information on the vintage of the home, as well as heating and water heating energy use in each home. The survey also included household characteristics such as the physical characteristics of housing units, household demographics, information about other heating and cooling products, fuels used, energy consumption and expenditures, and other relevant data. DOE used the household samples not only to determine boiler annual energy consumption, but also as the basis for conducting the LCC and PBP analysis. DOE used data from RECS 2009 together with AHRI shipment data by State [33] to project household weights and characteristics in 2020, the expected compliance date of any amended energy conservation standards for residential boilers at the time of the NOPR.

Commenting on the NOPR, AHRI stated that it appears that DOE significantly overestimated the number of buildings that use a residential boiler for space heating, as RECS 2009 indicates 11 million housing units use a gas-fired or oil-fired hydronic heating system, and not 16.6 million as shown in the NOPR TSD. (AHRI, No. 64 at p. 10) In response, it appears that AHRI is referring to Table 7.2.1 in the NOPR TSD, which shows the number of RECS records (and the corresponding number of houses represented by those records) used for each boiler product class. The total of these records and corresponding number of houses is not an estimate of the number of buildings that use a residential boiler for space heating. In fact, the total is not relevant in any way. Because RECS 2009 does not report the heating medium (hot water or steam), DOE used samples for hot water and steam boiler product classes that include all houses that might use either hot water or steam. For steam boilers in particular, this results in a sample size that represents many more houses than actually use steam boilers.

DOE accounted for applications of residential boilers in commercial buildings because the intent of the analysis of consumer impacts is to capture the full range of usage conditions for these products. DOE considers the definition of ''residential boiler'' to be limited only by its capacity.[34] DOE determined that these applications represent about 7 percent of the residential boiler market. DOE

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to the large volume of equipment purchased, and perform the installation themselves.

[28] *Heating, Air Conditioning & Refrigeration Distributors International 2013 Profit Report* (Available at: *http://hardinet.org/*) (Last accessed April 10, 2014).

[29] U.S. Census Bureau, *2012 Economic Census Data* (2012) (Available at: *http://www.census.gov/econ/*) (Last accessed March 4, 2015).

[30] Air Conditioning Contractors of America (ACCA), *Financial Analysis for the HVACR Contracting Industry: 2005* (Available at: *https://www.acca.org/home*) (Last accessed April 10, 2013).

[31] Sales Tax Clearinghouse Inc., State Sales Tax Rates Along with Combined Average City and County Rates, 2015 (Available at: *http://thestc.com/STrates.stm*) (Last accessed Sept. 1, 2015).

[32] U.S. Department of Energy: Energy Information Administration, Residential Energy Consumption Survey: 2009 RECS Survey Data (2013) (Available at: *http://www.eia.gov/consumption/residential/data/2009/*) (Last accessed October, 2015).

[33] Air-Conditioning, Heating, and Refrigeration Institute (AHRI), Confidential Shipment data for 2003–2012.

[34] 42 U.S.C. 6291(23).

used the EIA's 2003 Commercial Building Energy Consumption Survey [35] (CBECS 2003) to establish a sample of commercial buildings using residential boilers for each boiler product class.[36] Criteria were developed to help size these boilers using several variables, including building square footage and estimated supply water temperature. For boilers used in multi-family housing, DOE used the RECS 2009 sample discussed above, accounting for situations where more than one residential boiler is used to heat a building.

AHRI stated that an analysis that uses national data is not adequately evaluating the market for residential boilers in the U.S., which is concentrated in the Northeast and in older homes, and for which national average statistics are not representative. (AHRI, No. 64 at p. 10) In response, DOE is well aware of the regionality of the residential boiler market. The LCC analysis does not select buildings across the nation at random, but rather selects the homes and buildings reported by RECS 2009 and CBECS 2003 that have residential boilers; the RECS 2009- and CBECS 2003-derived sample reflects the actual distribution of residential gas-fired or oil-fired boilers in the U.S., and the weighting of the samples is adjusted to match the shipments by State from 2008–2012 provided by AHRI.[37] Additionally, DOE did not use national average values in its LCC analysis, but rather the specific data for each household or building reported by RECS 2009 and CBECS 2003 to determine the energy use of each boiler. Most of the data used in the LCC analysis are disaggregated by RECS 2009 regions or CBECS 2003 Census divisions. See appendix 7A of the final rule TSD for more details.

2. Space Heating Energy Use

For the NOPR, to estimate the annual energy consumption of boilers meeting higher efficiency levels, DOE first calculated the heating load based on the RECS and CBECS estimates of the annual energy consumption of the boiler for each household. DOE estimated the house heating load by reference to the existing boiler's characteristics, specifically its capacity and efficiency (AFUE), as well as by the heat generated from the electrical components. DOE used an oversize factor of 0.7 (*i.e.,* the boiler is 70 percent larger than it needs to be to fulfil the house heating load) from the DOE test procedure to determine the capacity of the existing boiler. The AFUE of the existing boilers was determined using the boiler vintage (the year of installation of the product) from RECS and historical data on the market share of boilers by AFUE. DOE then used the house heating load to determine the burner operating hours, which are needed to calculate the fossil fuel consumption and electricity consumption based on the DOE residential furnace and boiler test procedure.

Commenting on the NOPR, AHRI stated that DOE's average annual energy use estimates (95.3 MMBtu/year for gas-fired hot water boilers, 98.1 MMBtu/year for gas-fired steam boilers, 98.1 MMBtu/year for oil-fired hot water boilers, 99.9 MMBtu/year for oil-fired steam boilers) are almost twice the RECS national average annual space heating energy consumption for housing units using natural gas of 51.4 million Btus and almost 40 percent higher than the RECS national average annual space heating energy consumption for housing units using fuel oil of 70.3 million Btus. (AHRI, No. 64 at p. 12)

The primary reasons for the differences between the national RECS result and DOE's estimates are: (1) DOE's analysis recognizes that the boilers are mostly installed in colder climates, and (2) DOE accounts for residential boilers in commercial buildings. Since boilers are mostly installed in colder climates, the average energy use of boilers is significantly higher than the average space heating national energy use. Based on 2008–2012 AHRI shipments data by State and RECS 2009 households, almost 70 percent of gas-fired boilers and 90 percent of oil-fired boilers are installed in the Northeast. In 2009, based on RECS 2009 and 2008–2012 AHRI shipments data, the average annual space heating energy consumption is 75.8 MMBtu/yr for housing units with gas-fired hot water boilers. For the NOPR, DOE assumed that 7 percent of residential boilers are installed in commercial applications. In 2003, based on CBECS 2003 data and 2008–2012 AHRI shipments data, DOE estimated that average annual space heating energy consumption is 356.8 MMBtu/yr for buildings with gas-fired hot water boilers. The resulting weighted average results are 95.3 MMBtu/yr for buildings with gas-fired hot water boilers. For the NOPR and final rule, these numbers are adjusted to take into account: 2008–2012 AHRI shipments data by State, typical heating degree days (HDD) for an average year, HDD trends, building shell efficiency, number of boilers per household or building, automatic means, and secondary heating equipment. Based on these adjustments, for the final rule, DOE estimated that the average annual shipment-weighted energy use is 56.7 MMBtu/yr for gas-fired hot water boilers in residential applications and 205.9 MMBtu/yr in commercial applications in 2021 (or 68.6 MMBtu/yr for both residential and commercial buildings). For gas-fired hot water boilers, the 2021 estimates are about 30 percent lower than the estimated values in RECS 2009 or CBECS 2003. The results for the other boiler product classes are similar. See chapter 7 of the final rule TSD for more details about the energy use methodology and results.

Commenting on the NOPR, Energy Kinetics stated that DOE should use both the 0.7 oversizing factor and the demonstrated oversizing factors between three and four used in the NODA for the installed base of equipment. (Energy Kinetics, No. 52 at p. 3) DOE agrees that the oversize factor varies for each household. For the final rule, DOE revised the equipment sizing criteria to match historical shipments by capacity, which accounts for the variability of the oversize factor found in the field.

DOE adjusted the energy use to normalize for weather by using long-term heating degree-day (HDD) data for each geographical region.[38] For the NOPR, DOE also accounted for change in building shell characteristics between 2009 and 2020 by applying the building shell efficiency indexes in the National Energy Modeling System (NEMS) based on EIA's *Annual Energy Outlook 2013 (AEO 2013)*.[39] DOE also accounted for future heating season climate based on *AEO 2013* HDD projections.

AHRI questioned the applicability of the building shell efficiency index to multi-family or row houses with shared walls. (AHRI, Public Meeting Transcript, No. 50 at p. 83) In response, the *AEO* building shell efficiency index

[35] U.S. Department of Energy: Energy Information Administration, *Commercial Buildings Energy Consumption Survey* (2003) (Available at: *http://www.eia.gov/consumption/commercial/data/2003/index.cfm?view=microdata*) (Last accessed October, 2015).

[36] CBECS 2012 was not available at the time of the analysis. The full CBECS 2012 dataset is expected to be available in February 2016.

[37] Air-Conditioning Heating and Refrigeration Institute (AHRI), *2003–2012 Residential Boilers Shipments Data (Provided to Lawrence Berkeley National Laboratory)* (Last accessed November 15, 2013).

[38] National Oceanic and Atmospheric Administration, NNDC Climate Data Online (Available at: *http://www7.ncdc.noaa.gov/CDO/CDODivisionalSelect.jsp*) (Last accessed October 15, 2013).

[39] U.S. Department of Energy-Energy Information Administration, *Annual Energy Outlook 2013 with Projections to 2040* (Available at: <*http://www.eia.gov/forecasts/aeo/*>).

is an average intended to reflect all building types in general. Indexes that are specific to building types are not available. In any case, if DOE were to assume that the building shell efficiency of multi-family or row houses increases less than all buildings in general (as is likely to be the case), the projected heating load of such buildings would be higher than assumed in DOE's analysis, and the energy savings for the higher-efficiency boilers would be greater. DOE prefers to be conservative and not over-estimate the savings for this building sub-type. For the final rule, DOE used the building shell efficiency index from *AEO 2015* and a compliance year of 2021.[40] DOE also used the latest HDD projections from *AEO 2015* and updated the long-term HDD data.[41]

a. Impact of Return Water Temperature on Efficiency

For the NOPR, DOE accounted for boiler operational efficiency in specific installations by adjusting the AFUE of the sampled boiler based on an average system return water temperature. The criteria used to determine the return water temperature of the boiler system included consideration of building vintage, product type (condensing or non-condensing, single-stage or modulating), and whether the boiler employed an automatic means for adjusting water temperature. Using product type and system return water temperature, DOE developed and applied the AFUE adjustments based on average heating season return water temperatures.

Commenting on the NOPR, Burnham tested a condensing gas boiler and a non-condensing oil boiler to determine the impact of return water temperature on boiler efficiency. Burnham stated that, based on its test results, DOE is overstating the impact of water temperature on both gas-fired and oil-fired non-condensing boilers. Burnham recommended that the correction factor for non-condensing boilers should be about half that estimated by DOE for the NOPR (which was 1 percent). (Burnham, No. 60 at pp. 21–22) For condensing boilers, Burnham stated that DOE's assumed 2.5-percent reduction to adjust for return water temperature is low, especially at 92-percent and 96-percent AFUE, where the reduction is probably more like 4.5 percent and 6.5 percent, respectively. (Burnham, No. 60 at p. 66)

For the final rule, for non-condensing boilers, DOE used the data provided by Burnham to determine the impact of return water temperature on boiler efficiency. To determine the adjustment for condensing boilers, DOE collected data on several more model series in addition to the data provided by Burnham, which appear to refer to a 91-percent AFUE boiler and to show a decrease of approximately 3.3 to 3.5 percent in efficiency for boilers operating with return water temperatures between 120 and 140 °F. The other sources indicate a lower decrease than the data on a single Burnham boiler. Based upon all of the data, DOE estimated a reduction in efficiency of about 2.1 percent for condensing boilers. Regarding Burnham's comment that the reduction is higher at 92-percent and 96-percent AFUE, DOE did not find sufficient evidence to justify varying the percent decrease by AFUE. See appendix 7B of the final rule TSD for additional details.

b. Impact of Automatic Means for Adjusting Water Temperature on Energy Use

For the NOPR, DOE incorporated the impact of automatic temperature reset means on boiler energy use by adjusting AFUE based on a reduction in average return water temperature (RWT). DOE calculated the reduction in average RWT for single-stage boilers based on the duration of burner operating hours at reduced RWT. For modulating boilers, DOE used the average relationship[42] between RWT and thermal efficiency to establish the magnitude of the efficiency adjustment required for the high- and low-temperature applications. DOE maintained the same approach for the final rule. See appendix 7B of the final rule TSD for details on how DOE calculated the adjustment for automatic means.

AHRI stated that DOE's underestimated the benefit of the ''automatic means'' that is now provided with residential boilers. AHRI acknowledged that the TSD provides the calculation for adjusting the AFUE to account for the benefit of the automatic means; however, the adjustment for single-stage non-condensing boilers results in only a 0.05-percent AFUE improvement, which is based on the improvement of steady-state efficiency with a 2 °F reduction of the return water temperature. According to AHRI, studies have shown that this device or control feature does reduce the energy consumption of boilers in the field. A conservative estimate of the savings from automatic means would be 5 percent, but a more realistic range is 5 to 8 percent. (AHRI, No. 64 at p. 12)

DOE found that the majority of single-stage products sampled utilized a pre-purge control function that allows the purging of residual heat within the boiler prior to ignition of the burner. DOE also found that the majority of boiler models sampled incorporate a time limit and a low temperature limit function within the control strategy. The time limits range from two to three minutes (by default), with some boilers allowing for user-defined durations. DOE's research has shown that there is limited field and test data on the effectiveness of the pre-purge technology, which is the primary technology in single-stage non-condensing boilers to implement the automatic means design requirement. Based on the logic described in appendix 7B of the final rule TSD, the impact on boiler steady-state efficiency appears to be small. In its analysis, DOE accounts for the variability of idle losses during the non-heating season, which already takes into account for some automatic means improvements from different technologies (*e.g.,* outdoor reset). For the rule, because of limited availability of field and test data, DOE kept its NOPR approach for determining the impact of the automatic means on residential boiler efficiency.

c. Impact of Jacket Losses on Energy Use

For the NOPR, DOE also accounted for jacket losses when the boiler is located in a non-conditioned space (*i.e.,* unconditioned basement or garage). For boilers located in conditioned spaces, DOE assumed that jacket losses contribute to space heating as useful heat. See appendix 8C of the final rule TSD for details about how DOE determined the installation location of boilers.

AHRI stated that DOE assumes that 35 percent of residential gas-fired boilers and 53 percent of residential oil-fired boilers are installed in unconditioned spaces. AHRI questioned the validity of these estimates, since most boilers in homes in the Northeast Census region are installed in unconditioned basements that are part of the home, which still adds heat to the interior of

[40] U.S. Department of Energy-Energy Information Administration, *Annual Energy Outlook 2015 with Projections to 2040* (Available at: <*http://www.eia.gov/forecasts/aeo/*>).

[41] National Oceanic and Atmospheric Administration, NNDC Climate Data Online (Available at: *http://www7.ncdc.noaa.gov/CDO/CDODivisionalSelect.jsp*) (Last accessed October 15, 2015).

[42] Appendix 7B includes a list of references used to derive the relationship. No information is available about the relationship between AFUE and RWT, while manufacturers publish data on the relationship between boiler thermal efficiency and the RWT. DOE assumed that AFUE scales according to the relationship reported for the thermal efficiency.

the structure, such that it is not totally wasted energy. According to AHRI, the analysis should recognize that. Furthermore, AHRI argued that the jacket losses assumed in DOE's analysis randomly favor condensing boilers. According to AHRI, DOE assumes that jacket losses for high-mass boilers are equal to the jacket loss factor, CJ, for boilers installed as isolated combustion systems (ICS), but decides to assume that CJ for low-mass boilers is a tenth of this value (*i.e.,* 0.24), instead of using the value provided in ASHRAE 103–2007 for finned-tube boilers (*i.e.,* 0.5). This assumes that condensing boilers, which account for a greater proportion of low-mass boilers, will have lower jacket loss values than those assumed in the test procedure. Additionally, these jacket loss factors are only one portion of the total jacket loss, which is the jacket loss factor multiplied by the jacket loss measured during steady-state operation. Assuming these factors, DOE has made a determination that the jacket loss is equal to 1.0 percent, which is the default jacket loss used if this value is not measured by test. According to AHRI, the 1.0 percent value is a conservative estimate, and DOE should evaluate the total jacket losses with a more representative jacket loss value, suggesting that a value closer to 0.5 percent would be more appropriate. (AHRI, No. 64 at p. 14)

DOE estimates the location of the boiler based on the household characteristics in the RECS 2009 housing sample.[43] This takes into account that the majority of the boilers are installed in Northeast or Midwest, where basements are a commonly used to install boilers. RECS 2009 reports both if the household has a basement and whether the basement is conditioned or unconditioned. For the final rule, DOE used the same approach for determining the installation location of boilers. In regards to the jacket loss values, since there are very limited test data and because some of the jacket losses could contribute to heating the conditioned space, for the final rule, DOE revised its jacket loss factor value for condensing boilers so that it is equal to on average 0.5 (ASHRAE 103–2007 for finned-tube boilers), which would more closely approximate condensing boiler designs, and assumed 0.5 percent for the jacket loss fraction.

3. Water Heating Energy Use

DOE is aware that some residential boilers have the ability to provide both space heating and domestic water heating, and that these products are widely available and may vary greatly in design. For these applications, DOE accounted for the boiler energy used for domestic water heating, which is part of the total annual boiler energy use. For the NOPR, DOE used the RECS 2009 and/or CBECS 2003 data to identify households or buildings with boilers that use the same fuel type for space and water heating, and then assumed that a fraction of these identified households/buildings use the boiler for both applications.

Burnham stated that gas-fired steam boilers are seldom used to make domestic hot water due to technological challenges, and gas-fired steam boilers that can produce domestic hot water are not readily available in the market. Burnham believes that the fraction of gas-fired steam boilers used to make domestic hot water is less than 10 percent of all such boilers. Burnham stated that there is greater incentive to use oil-fired steam boilers to also make domestic hot water, in order to eliminate the additional maintenance and potential fuel piping complexities of a second oil burner. (Burnham, No. 60 at pp. 22–24, 66) For the final rule, based on AHRI's contractor survey, DOE assumed that 5 percent of gas-fired steam boilers and 10 percent of oil-fired steam boilers are used to make domestic hot water.

For the NOPR, to calculate the annual water-heating energy use for each boiler efficiency level, DOE first calculated the water-heating load by multiplying the annual fuel consumption for water heating (derived from RECS or CBECS) by the recovery efficiency for water heating of the existing boiler, which was calculated based on an adjustment to AFUE. DOE then calculated the boiler energy use for each efficiency level by multiplying the water-heating load by the recovery efficiency of the selected efficiency level.

Commenting on the NOPR, AHRI stated that the average water heating energy use values seem high. (AHRI, Public Meeting Transcript, No. 50 at p. 114) In response, the water heating energy use is higher for the boiler sample than the national average because boilers are primarily located in the northeast, with colder inlet water and colder ambient temperature. In addition, the NOPR-reported value included idle losses and commercial applications, which comprise seven percent of the entire boiler sample and use significantly more hot water than residential households.

a. Idle Loss

Idle loss, as the term applies to residential heating boilers, is heat wasted when the burner is not firing. The idle losses are the heat from combustion that is not transferred to the heating of water, including the products of combustion up the flue, the loss out of the heat exchanger walls and boiler's jacket (in the form of radiant, conductive, or convective transfer), and the loss down the drain as a condensate. Because no fuel is being consumed in the off-cycle, off-cycle losses are important only to the extent that they must be replaced during the on-cycle by the burning of extra fuel (*i.e.,* longer burner on times or higher firing rates). The DOE test procedure accounts for idle losses associated with space heating in the heating season efficiency value, but the idle losses during non-space heating operation (*i.e.,* domestic water heating) are not captured in the existing DOE test procedure.

For the NOPR analysis, DOE accounted for idle losses during non-space heating operation based on the installation location of the boiler (conditioned or unconditioned space), type of boiler (high mass or low mass), and whether or not the boiler served domestic hot water loads. For boilers that serve only space heating loads, the idle losses are accounted for in the heating season efficiency. For boilers that provided domestic hot water heating, idle losses occur in both heating and non-heating seasons. These idle losses were accounted for by applying heat loss values to the boiler and storage tank (when necessary) for a fraction of the off-cycle time. DOE also accounted for the losses for boilers that are installed with indirect tanks or tankless coils.

Energy Kinetics and PHCC stated that for non-condensing boilers, increasing the heat exchanger area to increase efficiency will add mass to the boiler, thereby increasing the idle loss of the system. Energy Kinetics stated that this significantly impacts the actual annual efficiency, and PHCC further elaborated that the increased losses could offset the operating efficiency gains. (Energy Kinetics, Public Meeting Transcript, No. 50 at p. 286; PHCC, No. 61 at p. 1)

For non-condensing boilers, DOE assumes that the idle loss does not necessarily increase with increased efficiency, based upon DOE's models series at different efficiency and available test data.[44] In addition to

[43] DOE assumed that all residential boilers in commercial buildings are installed in a conditioned space.

[44] Butcher, Thomas A., *Performance of Integrated Hydronic Heating Systems,* Brookhaven National

Continued

increasing heat exchanger area, manufacturers have a number of ways they can achieve higher efficiency for non-condensing boilers, including applying improved heat transfer measures or adding mechanical draft. For the final rule, DOE's approach accounts for the idle losses varying significantly regardless of AFUE or mass based on the test data. See appendix 7B of the final rule TSD for additional details on the consideration of idle losses.

4. Electricity Use

For the NOPR, DOE calculated boiler electricity consumption for the circulating pump, the draft inducer,[45] and the ignition system. In addition, DOE included the electricity use for a condensate pump or heat tape, which is sometimes installed with higher-efficiency products. For single-stage boilers, DOE calculated the electricity consumption as the sum of the electrical energy used during boiler operation for space heating, water heating, and standby energy consumption. For two-stage and modulating products, this formula includes parameters for the operation at full, modulating, and reduced load.

Commenting on the NOPR, Weil-McLain and Burnham stated that boilers at 85-percent AFUE are likely to require mechanical draft assistance, which would increase electricity use. (Weil-McLain, No. 55 at pp. 2–3; Burnham, No. 60 at p. 25) As stated in section IV.F.2, for the final rule, DOE revised the mechanical draft fractions for 85-percent AFUE gas-fired hot water boilers based on shipments data from Burnham, AHRI's contractor survey, and the updated reduced set of residential boiler models (hereinafter referred to as the ''reduced set''; see appendix 7D of the final rule TSD for details). (*See* Burnham, No. 60 at p. 18, 25; AHRI, No. 66 at p. 10–11)

Burnham stated that natural draft burner systems generally use a 40VA transformer to power the burner and controls, rendering DOE's estimate of 40W for non-condensing gas-fired hot water boilers and gas-fired steam boilers very conservative. (Burnham, No. 60 at p. 66) For the final rule, DOE revised the boiler power use estimates based on the updated reduced set of residential boiler models, which resulted in an estimate of 92 W for non-condensing gas-fired hot water boilers and 84 W for non-condensing gas-fired steam boilers.

Burnham stated that all oil-fired boilers are equipped with a fan as part of burner, so it is unclear what model DOE would consider an oil-fired boiler without an induced/forced draft. (Burnham, No. 60 at p. 24) For the final rule, DOE agrees that all oil-fired boilers are equipped with burner fans and revised the boiler power use estimates to include the burner fan electricity.

Burnham stated that DOE's analysis failed to recognize that condensing boilers typically have a separate pump to circulate water through the boiler's heat exchanger in addition to the pump used to circulate water through the heating system. (Burnham, No. 60 at p. 24, 66) In addition, Burnham stated that the power consumption for the boiler pump should be at least 160W. (Burnham, No. 60 at p. 24) For the final rule, for condensing boilers, DOE included the electricity use of both a boiler pump and circulating pump. DOE maintained the NOPR assumption that the circulating pump uses 80W. The engineering analysis determined that the most commonly used boiler pumps (*i.e.,* pumps that circulate water through the hot water boiler heat exchanger) are the Taco 0015 or Grundfos UPS 15, which use 120W. DOE utilized this value for all boiler pumps used in condensing boiler installations.

a. Standby Mode and Off Mode Losses

Lochinvar stated that the DOE erroneously presumes that standby power consumption is lost energy, but because boilers are typically installed inside homes, standby power consumption is converted into heat that is transmitted into the home. In contrast, Lochinvar stated that off mode power consumption should be considered a loss because there is likely no need for heating when the boiler is in off mode. (Lochinvar, No. 63 at pp. 2–3) For the final rule, DOE assumed that a fraction of standby power used by boilers installed indoors contributes to heating the home during the heating season. DOE agrees that off mode energy use does not contribute to heating the home.

b. Air Conditioner Electricity Use

For the NOPR, DOE accounted for the impact of water heating energy use during the non-heating season on air conditioner (AC) electricity use for boilers installed in conditioned spaces. DOE assumed that only boilers installed in indoor spaces impact the cooling load and that a fraction of this electricity use impacts the cooling load. EEI stated that if the boiler is not located near the thermostat, it will not have an impact on the cooling load, especially because the heat losses of the boiler are miniscule compared to the cooling load. (EEI, Public Meeting Transcript, No. 50 at p. 120) In NOPR and in the final rule, DOE assumed that about half of the energy use losses related water heating by the boiler as impacting cooling load to account boiler installation location, distance from thermostat, and non-coincidental loads.

5. *Standby Mode and Off Mode*

DOE calculated boiler standby mode and off mode electricity consumption for times when the boiler is not in use for each efficiency level identified in the engineering analysis for standby mode and off mode standards. DOE calculated boiler standby mode and off mode electricity consumption by multiplying the power consumption at each efficiency level by the number of standby mode and off mode hours. To calculate the annual number of standby mode and off mode hours for each sample household, DOE subtracted the estimated total burner operating hours (for both space heating and water heating) from the total hours in a year (8,760). Details of the method are provided in chapter 7 of the final rule TSD.

F. Life-Cycle Cost and Payback Period Analysis

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

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

• The PBP (payback period) is the estimated amount of time (in years) it takes consumers to recover the increased purchase cost (including installation) of a more-efficient product

Laboratory (December 2007) (Available at: <*https://www.bnl.gov/isd/documents/41399.pdf*>).

[45] In the case of modulating condensing boilers, to accommodate lower firing rates, the inducer will provide lower combustion airflow to regulate the excess air in the combustion process. DOE assumed that modulating condensing boilers are equipped with inducer fans with permanent split capacitor (PSC) motors and two-stage controls. The inducers are assumed to run at a 70-percent airflow rate when the modulating unit operates at low-fire.

through lower operating costs. DOE calculates the PBP by dividing the change in purchase cost at higher efficiency levels by the change in annual operating cost for the year that amended or new standards are assumed to take effect.

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

For each considered efficiency level in each product class, DOE calculated the LCC and PBP for a nationally representative set of housing units and commercial buildings. As stated previously, DOE developed household and building samples from the RECS 2009 and CBECS 2003. For each sample building, DOE determined the energy consumption for the residential boilers and the appropriate energy prices. By developing a representative sample of buildings, the analysis captured the variability in energy consumption and energy prices associated with the use of residential boilers.

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

DOE conducts a stochastic analysis that employs a computer spreadsheet model to calculate the LCC and PBP, which incorporates Crystal Ball™ (a commercially-available software program) and relies on a Monte Carlo simulation to incorporate uncertainty and variability (*e.g.,* energy prices, installation costs, and repair and maintenance costs) into the analysis. The Monte Carlo simulations randomly sample input values from the probability distributions and residential boiler user samples. It uses weighting factors to account for distributions of shipments to different building types and States to generate LCC savings by efficiency level. The model calculated the LCC and PBP for products at each efficiency level for 10,000 buildings per simulation run.

Commenting on the NOPR, AHRI stated that information from a recently completed study conducted by the Gas Technology Institute (GTI)[46] indicates that the random-choice Monte Carlo methodology used in the LCC fails to acknowledge the rational, economic factors involved in purchasing heating equipment, including boilers. AHRI stated that these factors may vary, but the ultimate decision on what unit is purchased is based on some logic underscored by the consumer's economic situation. (AHRI, No. 64 at p. 10) Burnham supported AHRI's position. (Burnham, No. 60 at p. 19)

In response, the method used to estimate the boiler efficiency that a given sample household would choose in the no-new-standards case is not entirely random. For gas boilers, DOE assigned a higher fraction of condensing boilers to regions with a higher fraction of condensing shipments, as reported in the shipments data. That is, the method assumes that the factors that currently cause consumers to choose condensing boilers in specific areas will continue to operate in the future. Development of a complete consumer choice model for boiler efficiency would require data that are not currently available, as well as recognition of the various factors that impact the purchasing decision, such as incentives, the value that some consumers place on efficiency apart from economics (*i.e.,* ''green behavior''), and whether the purchaser is a homeowner, landlord, or builder. For the final rule, DOE used the same general method to assign boiler efficiency in the no-new-standards case, but made use of updated shipments data.

DOE calculated the LCC and PBP for all consumers of residential boilers as if each were to purchase a new product in the expected year of required compliance with amended standards. Any amended standards would apply to residential boilers manufactured 5 years after the date on which any amended standard is published.[47] At this time, DOE estimates publication of a final rule in 2016. Therefore, for purposes of its final rule analysis, DOE used 2021 as the first year of compliance with any amended standards for residential boilers.

As noted above, DOE's LCC and PBP analyses generate values that calculate the payback period for consumers under potential energy conservation standards, which includes, but is not limited to, the three-year payback period 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. 6295(o)(2)(B)(i). 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).

Table IV.24 summarizes the approach and data DOE used to derive inputs to the LCC and PBP calculations. The subsections that follow provide further discussion. Details of the spreadsheet model, and of all the inputs to the LCC and PBP analyses, are contained in chapter 8 of the final rule TSD and its appendices.

TABLE IV.24—SUMMARY OF INPUTS AND METHODS FOR THE FINAL RULE LCC AND PBP ANALYSIS*

Inputs	Source/method
Product Cost	Derived by multiplying MPCs by manufacturer, wholesaler, and contractor markups and sales tax, as appropriate. Used a constant product price trend to forecast product costs.
Installation Costs	Baseline installation cost determined with data from RS Means. Assumed cost changes with efficiency level.
Annual Energy Use	The total space heating and water heating fuel use plus electricity use per year. Number of operating hours and energy use based on RECS 2009 and CBECS 2003.

[46] Available at: *http://www.gastechnology.org/reports_software/Documents/21693-Furnace-NOPR-Analysis-FinalReport_2015-07-15.pdf.*

[47] DOE is conducting this rulemaking pursuant to 42 U.S.C. 6295(f)(4)(C), which provides a 5-year lead time for compliance with amended standards. This rulemaking also satisfies DOE's 6-year-lookback review requirement under 42 U.S.C. 6295(m), which provides the same 5-year lead time.

TABLE IV.24—SUMMARY OF INPUTS AND METHODS FOR THE FINAL RULE LCC AND PBP ANALYSIS*—Continued

Inputs	Source/method
Energy Prices	Natural Gas: Based on EIA's Natural Gas Navigator data for 2013. Fuel Oil and LPG: Based on EIA's State Energy Consumption, Price, and Expenditures Estimates (SEDS) for 2013. Electricity: Based on EIA's Form 861 data for 2013. Variability: Regional energy prices determined for 30 regions for RECS 2009 sample and 9 Census divisions for the CBECS 2003 sample.
Energy Price Trends	Based on *AEO 2015* price forecasts.
Repair and Maintenance Costs	Based on RS Means data and other sources. Assumed variation in cost by efficiency.
Product Lifetime	Based on shipments data, multi-year RECS and American Housing Survey data, and AHRI contractor survey.
Discount Rates	Approach involves identifying all possible debt or asset classes that might be used to purchase the considered appliances, or might be affected indirectly. Primary data source was the Federal Reserve Board's Survey of Consumer Finances.
Compliance Date	2021.

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

1. Product Cost

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

To project future product prices, DOE considered the historic trend in the Producer Price Index (PPI) for cast iron heating boilers and steel heating boilers[48] to estimate the change in price between the present and the compliance years. Due to the variability in the historical price trends, DOE assumed a constant product price trend.

2. Installation Cost

Installation cost includes labor, overhead, and any miscellaneous materials and parts needed to install the product, such as venting and piping modifications and condensate disposal that might be required when installing products at various efficiency levels. DOE estimated the costs associated with installing a boiler in a new housing unit or as a replacement for an existing boiler.

a. Basic Installation Cost

For the NOPR, DOE calculated the basic installation cost, which is applicable to both replacement and new construction boiler installations and includes the cost of putting in place and setting up the boiler, permitting, and removal or disposal fees.

b. Replacement Installations

For the NOPR, DOE considered additional costs (''adders'') for a fraction of replacement installations of non-condensing and condensing boilers. These additional costs may account for chimney relining, updating of flue vent connectors, vent resizing, and the costs for a stainless steel vent, if required. Each of these cost adders is discussed in further detail below.

(1) Chimney Relining

To determine the installations that would require chimney relining upon boiler replacement, DOE assumed for the NOPR that all boilers that were installed before 1995, the year that the National Fuel Gas Code (the first building code to require chimney lining) was established for all buildings built before 1995, would require relining upon boiler replacement in 2020.

Commenting on the NOPR, for the replacement of a non-condensing boiler with another non-condensing boiler, Crown Boiler stated that the National Fuel Gas Code (NFGC) does not always require relining indoor terracotta chimneys for all efficiency levels, and assuming that all boilers installed in homes built before 1995 or replaced before 1995 require relining upon replacement is incorrect and overstates the cost of a non-condensing boiler replacement. (Crown Boiler, Public Meeting Transcript, No. 50 at pp. 163–164, 197) Weil-McLain and AHRI stated that section 12.6.4.2 of the NFGC does not require chimneys to be relined when an appliance is replaced by an appliance of similar type. Therefore, the majority of boiler replacements involving a non-condensing cast iron boiler being replaced with the same type of equipment would not have included chimney relining, regardless of whether such replacement occurred prior to or after 1995. (Weil-McLain, No. 55 at p. 5; AHRI, No. 64 at p. 11)

For the final rule, DOE did not change its methodology to determine the fraction of unlined chimneys that would require relining applied in the NOPR analysis. Similar to the NOPR, DOE estimated that only 6 percent of all replacement boiler installations in 2021 would require relining of unlined chimneys, which overall seems to coincide with stakeholder input regarding the fraction of non-condensing replacement installations requiring venting modifications. Regarding the comments by Weil-McLain and AHRI, DOE notes that the exception in section 12.6.4.2 of the NFGC states that existing chimneys shall be permitted to have their use continued when an appliance is replaced by an appliance of similar type, input rating, and efficiency. However, DOE has concluded that many of the current non-condensing boiler designs (82-percent to 83-percent AFUE) cannot be considered to be of similar input rating and efficiency compared to old boilers below 80-percent AFUE that were primarily installed before 1992. Furthermore, DOE notes that section 12.6.4.4 of the NFGC states that ''When inspection revels that an existing chimney is not safe for the intended application, it shall be repaired, rebuilt, relined, or replaced with a vent or chimney to conform to National Fire Protection Association (NFPA) 211.''[49] Because the amended standard will be effective in 2021, many boilers installed before 1995 will be close to the end of their lifetime and they may be vented in chimneys that would require the relining of the existing chimney to meet safety requirements. Thus, for the final rule, DOE maintained the assumption that boilers that replace boilers installed before 1995, or first-time boilers installed in homes built before 1995, would require relining of the chimney.

[48] Cast iron heating boiler PPI series ID: PCU 3334143334141; Steel heating boiler PPI series ID: PCU 3334143334145 (Available at: *http://www.bls.gov/ppi/*.)

[49] National Fire Protection Association, *NFPA 211: Standard for Chimneys, Fireplaces, Vents, and Solid Fuel-Burning Appliances* (2013) (Available at: *http://www.nfpa.org/codes-and-standards/document-information-pages?mode=code&code=211*).

Weil-McLain stated that DOE used incorrect assumptions to calculate the percentage of households with an unlined chimney and the percentage of masonry chimneys that would need to be relined in 2021, because DOE incorrectly applied the NFGC in determining the number of relined chimneys. Weil-McLain also stated that there are significantly more households with a boiler in the north than in the south; therefore, using a midpoint between the percentages assigned to the north and to the south significantly underestimates the actual percentage of households with unlined chimneys. (Weil-McLain, No. 55 at p. 5)

DOE did not apply a national average fraction to determine the number of chimneys that would need to be relined in 2021. Rather, DOE used regional fractions of the number of masonry chimneys and the age of each individual boiler to determine whether a chimney would need to be relined in 2021. For both the NOPR and the final rule, DOE assumed that 73 percent of buildings in the Northeast, 53 percent of buildings in the Midwest, 10 percent of buildings in the South, and 27 percent of buildings in the West have masonry chimneys.

For the NOPR, DOE assumed that any chimney relining would require an aluminum liner. Burnham questioned whether the unit costs DOE used for double wall kit ''aluminum liners'' are actually for ''all fuel'' stainless steel liner kits (which are appropriate for oil-fired boilers). (Burnham, No. 60 at p. 26) For the NOPR, DOE used an average cost of different liners, including double wall kit ''aluminum liners'' that are actually for ''all fuel'' stainless steel liner kits. Burnham also stated that DOE does not need to extrapolate costs for 5″ and 6″ liners, as costs that better reflect true market costs are provided by DOE's data source.[50] (Burnham, No. 60 at p. 26) Furthermore, Weil-McLain stated that the fact that a chimney was re-lined for a non-condensing boiler does not necessarily mean that it was relined with stainless steel to meet the requirements for a condensing unit. (Weil-McLain, No. 55 at p. 5)

For the final rule, DOE updated its liner prices for different liner types and sizes (including 5″ and 6″) from the mentioned data source. It also applied the ''aluminum liner'' kit costs to Category I non-condensing gas-fired boilers and AL29–4C stainless steel liner kit costs to Category III non-condensing gas-fired boilers to meet the requirements of each venting category.

Burnham stated that DOE erroneously assumed that aluminum would be used as the liner material for oil-fired boilers, when it should be stainless steel. Burnham provided the cost for stainless steel liner systems for use with fuel oil from DOE's online vent source.[51] (Burnham, No. 60 at p. 26) For the final rule, DOE assumed that oil-fired boilers require stainless steel chimney liners, and used the cost from the online vent source.

(2) *Venting Characterization*

For the NOPR, to determine the venting installation costs, DOE considered vent categories as defined in the National Fuel Gas Code. DOE determined that all natural draft boilers and a fraction of mechanical draft boilers would be vented as a Category I appliance (negative pressure vent system with high temperature flue gases). DOE determined that the remaining fraction of mechanical draft boilers would be vented as a Category III appliance (positive pressure vent system with high temperature flue gases). DOE determined that very few non-condensing would be installed as a Category II appliance (negative pressure vent system with low temperature flue gases) or a Category IV appliance (positive pressure vent system with low flue gases temperatures). However, DOE determined that all condensing installations would be vented as a Category IV appliance.

DOE included additional venting cost associated with Category III stainless steel venting for a fraction of non-condensing installations that require such venting. Such inclusion addresses potential safety concerns by preventing the corrosive impacts of condensation in the venting system. Because use of an inducer or forced draft fan is associated with conditions under which stainless steel venting is necessary to avoid condensation in some cases, DOE based the fraction of boilers requiring stainless steel venting on the percentage of models with inducer or forced draft fans in the AHRI directory[52] and manufacturer literature. The fraction of stainless steel venting installations ranged from 11 percent for the baseline efficiency models to 32 percent for the 85-percent AFUE models.

Commenting on the NOPR, Weil-McLain, Burnham, AGA/APGA and PGW stated that replacement of existing non-condensing boilers (installed with current venting systems) with near-condensing boilers that do not use an inducer or forced draft fan requires Category II venting, because such units operate with a non-positive vent static pressure and with vent gas temperature that may cause excessive condensate production in the vent. Such venting uses materials (such as stainless steel alloy, AL29–4C) that can resist the corrosive nature of the condensate. (Weil-McLain, No. 55 at pp. 1–2, 4; Burnham, No. 60 at p. 9; AGA and APGA, No. 54 at p. 2; PGW, No. 57 at p. 1)

For the final rule, DOE estimated that in cases of replacement with near-condensing gas-fired boilers (85–89 percent AFUE), instead of using Category II stainless steel venting, installers would use Category III stainless steel venting with mechanical draft.[53] Category II venting presents reliability issues, even with stainless steel venting, because of the variety of operating conditions encountered in the field. For this analysis, DOE assumed that such installations (that otherwise would require Category II venting) would have less safety and reliability issues by installing a mechanical draft boiler with Category III venting, which requires stainless steel venting. DOE included the cost of AL29–4C stainless steel venting for all Category III installations. DOE also determined that the installation costs associated with Category III vent installations would be equal to or higher than Category II vent installations in most cases.

Burnham stated that the ANSI Z223.1 code defers to the manufacturer's installation and operation manual for Category II, III, and IV boilers. If the boiler has ANSI Z21.13 certification, the boiler manufacturer must either supply or specify venting materials meeting certain requirements for corrosion resistance and/or gas tightness in its manual. For Category II, III, and IV non-condensing boilers, the most common method of meeting this requirement is to specify the AL29–4C stainless steel special gas vent. (Burnham, No. 60 at p. 10) Burnham found from its review of 61 models in the AHRI directory that almost all non-condensing, non-Category I boilers are vented with an AL29–4C special gas vent, which increases the installation cost of these products. (Burnham, No. 60 at p. 27) For the NOPR and final rule, as stated

[50] Available at: *http://www.ventingpipe.com/gas-fuel-chimney-liners/c1650.*

[51] Available at: *http://www.ventingpipe.com/gas-fuel-chimney-liners/c1650?f3378=oil.*

[52] Air Conditioning, Heating, and Refrigeration Institute, Consumer's Directory of Certified Efficiency Ratings for Heating and Water Heating Equipment (AHRI Directory) (September 2013) (Available at: *http://www.ahridirectory.org/ahridirectory/pages/home.aspx*) (Last accessed September 2013).

[53] For replacement with an 84-percent AFUE boiler, DOE found that that it is necessary to use special venting in a small fraction of cases based on shipments data provided by Burnham.

above, DOE did not consider Category II or IV venting for non-condensing boilers, but instead for all category III non-condensing boilers, DOE included the cost for AL29–4C stainless steel venting.

Burnham stated that horizontal venting of a Category III or IV gas-fired boiler at 85-percent AFUE is limited by safety codes, building codes, I&O manuals, location of surrounding buildings, and limited access to an eligible exterior wall. It noted that this is particularly a problem in urban areas with homes that are closely spaced. Burnham stated that in cases where horizontal venting is impossible, it may be unreasonably expensive to use the old chimney as a chase for a special gas vent system. (Burnham, No. 60 at pp. 14–15) PGW stated that the installation of Category II and IV venting systems presents particular problems in Philadelphia's 400,000 row houses because replacing a boiler will require a new venting system, including abandonment of the existing venting system, structural changes to accommodate a new venting system path, and relocation of the boiler to meet the code and installation requirements of a new condensing boiler system. (PGW, No. 57 at p. 2) In addition, Burnham stated that conversion from a non-condensing Category I boiler to a non-condensing or condensing Category II, III, or IV boiler can result in an orphaned water heater. Burnham stated that if there is no way to horizontally vent the new boiler, and if the old chimney is used as a chase for the special vent system, the water heater and any other appliances vented into that chimney will need to be removed. Burnham stated that DOE needs to include the additional installation costs associated with complete replacement of ''orphaned water heaters'' for a fraction of installations. (Burnham, No. 60 at p. 28)

DOE acknowledges that a small fraction of replacement installations may be difficult, but DOE does not believe that the difficulties are insurmountable. DOE's analysis accounts for additional costs for those installations that would require re-routing of the vent system for Category III non-condensing boilers and Category IV condensing boilers to account for the limitations described by Burnham and PGW. The analysis does not include installations that would require the use of existing chimneys in lieu of horizontal venting, but rather included the cost for longer vent runs. DOE notes that in response to the NOPR for the current residential furnaces rulemaking, the American Council for an Energy-Efficient Economy (ACEEE) stated that the Energy Coordinating Agency, a major weatherization program in Philadelphia that has installed many condensing furnaces in row houses, has developed moderate cost solutions (at most $350) to common problems such as having no place to horizontally vent directly from the basement. ([Docket No. EERE–2014–BT–STD–0031], ACEEE, No. 113 at p. 7) Both in the NOPR and final rule, DOE accounted for a fraction of installations that would require chimney relining or vent resizing for the orphaned water heater. DOE did not consider the complete replacement of the orphaned water heater, but instead added additional installation costs associated with venting of the Category III or IV boiler, so that the orphaned water heater could be vented through the chimney.

Boilers that use mechanical draft (Category I) are required to meet the NFGC venting requirements, while Category III systems require mechanical draft and stainless steel venting. Burnham and Weil-McLain stated that DOE overstated the market share of units that use mechanical draft (Category I or III) because DOE used number of models instead of shipments. (Burnham, No. 60 at pp. 24–25; Weil-McLain, No. 55 at p. 5) In addition to data on models from the AHRI directory, for the final rule, DOE also used shipments data from Burnham and AHRI's contractor survey to estimate the share of installations that would use mechanical draft. (AHRI, No. 67) For the final rule, DOE also took into account a fraction of mechanical draft (Category I) gas-fired boilers that would need the vents to be resized to meet the NFGC venting requirements.

Weil-McLain stated that the vast majority of near-condensing gas-fired boilers [54] sold would have an inducer or fan (*i.e.,* mechanical draft). Weil-McLain stated that because boilers at 85 percent AFUE produce flue gases that have a low enough temperature that they do not have enough buoyancy to naturally be removed, they are more likely to require mechanical draft to vent the flue gases. Weil-McLain stated that in addition, the mandated use of an automatic means for adjusting water temperature also reduces the buoyancy of the flue gases, thereby necessitating mechanical draft. Weil-McLain also stated that the addition of a draft inducer or blower motor would increase the installation costs associated with new electric service installation (in some instances), new venting and/or chimney lining, and re-piping. (Weil-McLain, No. 55 at pp. 2–3)

For the final rule, DOE used shipments data from Burnham [55] and the AHRI contractor survey, which resulted in about half of 85-percent AFUE gas-fired hot water boilers shipped in 2021 being mechanical draft. Using this data, DOE also estimated that 5 percent of gas-fired hot water boilers at efficiency levels below 85-percent AFUE use mechanical draft in 2021. For the NOPR and final rule, DOE assumed that adding mechanical draft would significantly increase the venting costs due to new flue venting and/or chimney lining. For the final rule, DOE updated its installation costs for mechanical draft as mentioned above. DOE did not assume additional cost for new electric service, since all new gas-fired boilers utilize electronic ignition, which already requires an electrical outlet. In addition, DOE did not assume additional re-piping (to change the installation location of the boiler), but instead assumed that the boiler would remain in the same installation location, which might require additional vent length to address restrictions on horizontal venting.

Commenting on the NOPR, Burnham stated that in addition to straight pipes, the installation manuals of the models in the AHRI directory require at least one other fitting (90 degree elbow) in almost all Category III/IV installations. (Burnham, No. 60 at p. 28) For the NOPR and the final rule, DOE accounted for other fittings, such as a 90 degree elbow, for all venting installations.

For the NOPR, the additional installation costs for condensing boilers in replacement installations included new either 2-inch or 3-inch polyvinyl chloride (PVC), polypropylene (PP), or chlorinated polyvinyl chloride (CPVC) combustion air venting for direct vent installations (PVC); concealing vent pipes for indoor installations, addressing an orphaned water heater (by updating flue vent connectors, vent resizing, or chimney relining), and condensate removal.

Weil-McLain stated that with a Category IV boiler, the venting system must be able to handle positive pressure. This often eliminates the ability for the boiler to continue to use the same chimney as other appliances, which makes a retrofit with such an appliance all the more costly to the

[54] Weil-McLain considers near-condensing gas-fired boilers to be those with AFUE from 84 percent to 89 percent.

[55] Burnham shipments data from 2014 showed that 38.7 percent of its 85-percent AFUE gas-fired hot water boilers shipped in 2014 were mechanical draft.

consumer because alternative venting and piping configurations would be necessary. It stated that the additional costs for installing a boiler as a Category IV appliance are at least $1,000 to over $1,400, if there are no further complications. (Weil-McLain, No. 55 at p. 3) For the NOPR and the final rule, DOE accounted for the additional installation cost of adding a category IV vent for condensing boiler designs, including eliminating the ability of the boiler to continue to use the same chimney when it is also being used by water heater, resizing of orphaned water heater, and all necessary installation costs for adding a new flue vent.

Commenting on the NOPR, Burnham reviewed 44 condensing boiler models in the AHRI directory and found that most of the units with an input capacity of 100 MBH use 3-inch venting. Burnham stated that if DOE uses a representative gas-fired hot water boiler input capacity of 120 MBH as it recommends, the use of 3-inch venting is almost universal. (Burnham, No. 60 at p. 28) AHRI stated that after a certain input level, the standard PVC pipe in the vent system will be 3 inches. (AHRI, Public Meeting Transcript, No. 50 at p. 168) Crown Boiler added that with input rates at the upper limit of the residential range, some condensing boilers may need 4-inch vents. (Crown Boiler, Public Meeting Transcript, No. 50 at p. 169) For the final rule, DOE assumed that most condensing boilers use 3-inch PVC, PP, or CPVC pipes, and those at the highest capacities use 4-inch vents.

The Advocates encouraged DOE to incorporate the lower-cost DuraVent technologies in the analysis, and more broadly to consider innovative installation technology that would likely emerge with increasing experience and learning. The Advocates stated that the DuraVent technology can help address difficult installation situations with condensing boilers by allowing for venting both a new condensing boiler and an existing atmospheric water heater through the existing chimney. (The Advocates, No. 62 at p. 2) DOE did not include lower-cost venting solutions for condensing boilers because these technologies are still immature.[56] However, DOE agrees that if the new venting technologies are successful in the market, they could decrease the installation cost of condensing boilers in replacement situations.

(3) Other Issues

In the NOPR and final rule, DOE added condensate withdrawal costs for condensing boilers. Burnham stated that according to the I&O manuals of the boilers it examined, the vast majority of Category II, III, and IV vent systems require a means of disposing of condensate for non-condensing boilers, which DOE did not account for in its installation cost calculations. (Burnham, No. 60 at p. 28) Lochinvar stated that even non-condensing boilers will condense when the heat exchanger is cold. Lochinvar also stated that automatic means measures extend the time that heat exchangers are exposed to condensate, and increases the potential for condensate-related problems. (Lochinvar, No. 63 at pp. 2–3)

For the final rule, based on a review of installation manuals, DOE assumed that 75 percent of non-condensing mechanical draft category III boilers require condensate collection. DOE accounted for condensate issues in the venting by including a condensate trap and piping to either a collector or drain. DOE has determined that these measures also address the impact of automatic means as part of the overall condensate collection process.

For the NOPR, DOE assumed that the circulating pump and boiler pump are provided by the manufacturer, and, therefore, included the cost of both pumps as part of the product cost. Commenting on the NOPR, Burnham stated that in some cases, neither the circulation pump nor the boiler pump are supplied with the boiler, thereby increasing the installation cost. Burnham added that a second ramification of the need for two pumps are the associated piping requirements. In most cases, this piping is not supplied with the boiler and must be fabricated by the installer, which results in an additional cost. Burnham estimated that the contractor's cost associated with the second (boiler) pump and the piping is $239. (Burnham, No. 60 at pp. 29–31) For the final rule, DOE assumed that neither the circulation pump nor the boiler pump is supplied with the boiler. DOE included the installation of the secondary and primary piping 75 percent of the time for condensing boiler installations.

Burnham stated that 35 percent of the condensing gas-fired hot water boiler models it investigated requires a Y strainer. Burnham estimated that the contractor's cost of a 1-inch Y strainer is $45. (Burnham, No. 60 at pp. 29–31) For the final rule, DOE included the cost of a Y-strainer for one-third of condensing boiler installations based on a review of condensing model installation manuals, with an average installed cost of $48 (including labor and parts) from RS Means 2015.

c. New Construction Installations

DOE also included installation adders for new construction, as well as for new owner installations for hot water gas-fired boilers. For non-condensing boilers, the only adder is a new metal flue vent (including a fraction with stainless steel venting) and condensate withdrawal for a fraction of category III models. For condensing gas boilers, the additional costs for new construction installations related to potential amended standards include a new flue vent, combustion air venting for direct vent installations and accounting for a commonly-vented water heater, and condensate withdrawal.

d. Total Installation Cost

ACCA stated that its members found the installation cost for gas-fired hot water boilers, regardless of efficiency level or existing venting options, to be nearly twice as high as the average basic installation cost assumed by DOE of $2,741. ACCA stated that, for gas-fired steam boilers, the DOE analysis produced an average basic installation cost of $2,917, but feedback from ACCA's contractors suggest the real costs are twice that amount. ACCA also stated that the same discrepancy applies to both the oil-fired hot water boilers and the oil-fired steam boilers. (ACCA, No. 65 at p. 2)

In response, DOE notes that the basic installation cost, which consists of the installation costs that are common to all boilers, is only part of the total installation cost. In addition to the basic installation cost, the total installation cost includes venting costs and additional costs for condensing boiler installations. For the final rule, DOE's updated installation cost analysis, based on updated RS Means 2015 and stakeholder comments discussed above, resulted in an average total installation cost of $4,288 for a baseline (82-percent AFUE) gas-fired hot water boiler, which is close to the value suggested by ACCA. DOE's value is also close to the $4,500 installation cost for gas-fired hot water boilers (natural draft) from 82.0 to 83.9 percent AFUE in AHRI's contractor survey.

3. Annual Energy Consumption

For each sampled building, DOE determined the energy consumption for a residential boiler at different efficiency levels using the approach

[56] The chimney vent option, which would be most applicable to residential boilers, is still under development. The non-condensing (Category I) Type B vent + condensing (Category IV) venting option is currently available in the market: *http://duravent.com/Product.aspx?hProduct=49.*

described above in section IV.E of this document. The product energy consumption is the site energy use associated with providing space heating (and water heating in some cases) to the building.

DOE considered whether boiler energy use would likely be impacted by a direct rebound effect, which occurs when a product that is made more efficient is used more intensively, such that the expected energy savings from the efficiency improvement may not fully materialize. Such change in behavior when operating costs decline is known as a (direct) rebound effect. The take-back in energy consumption associated with the rebound effect provides consumers with increased value (*e.g.,* more comfortable indoor temperature). DOE believes that, if it were able to monetize the increased value to consumers of the rebound effect, this value would be similar in value to the foregone energy savings. Therefore, the economic impacts on consumers with or without the rebound effect, as measured in the LCC analysis, are the same.

4. Energy Prices

For the NOPR, DOE derived 2012 average and marginal monthly residential and commercial natural gas, fuel oil, LPG, and electricity prices using monthly data by State from Energy Information Administration. DOE assigned an appropriate energy price to each household or commercial building in the sample, depending on its location. To do this, DOE used the average 2008–2012 fraction of boiler shipments by State [57] to assign average and marginal prices for 30 geographical regions and 9 Census divisions to match the residential boiler samples derived from RECS 2009 sample and CBECS 2003. For the final rule, DOE derived 2013 average and marginal monthly residential and commercial natural gas, fuel oil, LPG, and electricity prices using updated data for 2013.[58 59 60]

Commenting on the NOPR, AGA and APGA argued that DOE's method of calculating marginal energy prices overstates the operating cost savings of higher-efficiency boilers. AGA and APGA stated that the marginal prices that AGA derived by deducting the fixed charge portion of the bill from the total bill range from 7 percent to 16 percent lower than the prices developed by DOE. (AGA and APGA, No. 54 at p. 2) Laclede stated that DOE's estimates for what is called ''marginal monthly natural gas prices'' are much higher than actual marginal prices that customers pay as reflected by impacts in energy consumption changes in their utility bills. (Laclede, No. 58 at p. 3)

In response to similar comments provided on the Residential Furnace notice of proposed rulemaking,[61] DOE developed seasonal marginal price factors for 23 gas tariffs provided by the Gas Technology Institute.[62] These marginal price factors can be compared to those developed by DOE from the EIA data. The winter price factors used by DOE are generally comparable to those computed from the tariff data, indicating that DOE's marginal price estimates are reasonable at average usage levels. The summer price factors, which are less relevant for analysis of boilers, are also generally comparable. Of the 23 tariffs analyzed, eight have multiple tiers, and of these eight, six have ascending rates and two have descending rates. Because this analysis uses an average of the two tiers as the commodity price, it will generally underestimate the marginal prices for consumers subject to the second tier. A full tariff-based analysis would require information about the household's total baseline gas usage (to establish which tier the consumer is in), and a weight factor for each tariff that determines how many customers are served by that utility on that tariff. These data are generally not available in the public domain. DOE's use of EIA State-level data effectively averages overall consumer sales in each State, and so incorporates information about all utilities. DOE's approach is, therefore, more likely to provide prices representative of a typical consumer than any individual tariff. For more details on this comparative analysis, refer to Appendix 8D of the final rule TSD.

For the NOPR, to estimate energy prices in future years, DOE multiplied the average regional energy prices by the forecast of annual change in national-average residential energy prices in the Reference case from *AEO 2013,* which has an end year of 2040. To estimate price trends after 2040, DOE used the average annual rate of change in prices from 2020 to 2040.

AHRI and Laclede stated that DOE should use *AEO 2015* rather than *AEO 2013.* (AHRI, No. 64 at p. 9; Laclede, No. 58 at p. 4) AHRI stated that it is incumbent on DOE to issue a supplemental notice of proposed rulemaking that revises the analysis based on *AEO 2015* data so that stakeholders may comment upon the analysis done using the most up-to-date inputs. (AHRI, No. 64 at p. 9) For the final rule, DOE has updated its analysis using *AEO 2015.* DOE has concluded that the differences between *AEO 2013* and *AEO 2015* are not large enough to warrant a supplemental notice of proposed rulemaking.

For a detailed discussion of the development of energy prices, see appendix 8D of the final rule TSD.

5. Maintenance and Repair Costs

Maintenance costs are associated with maintaining the operation of the product. For the NOPR, DOE estimated maintenance costs at each considered efficiency level using a variety of sources, including *2013 RS Means Facility Repair and Maintenance Data* [63] and manufacturer product literature. For AFUE standards analysis, DOE accounted for additional maintenance costs for condensing boilers associated with checking the condensate withdrawal system, replacing the neutralizer filter, and flushing the secondary heat exchanger for condensing oil boilers in high-sulfur oil-fuel regions. For standby and off mode standards, DOE assumed no additional maintenance costs for the baseline or higher-efficiency design options. The frequency with which the maintenance occurs was derived from RECS 2009 and CBECS 2003, as well as a 2008

[57] Air-Conditioning Heating and Refrigeration Institute (AHRI), *2003–2012 Residential Boilers Shipments Data (Provided to Lawrence Berkeley National Laboratory)* (November 15, 2013).

[58] U.S. Department of Energy-Energy Information Administration, *Form EIA–826 Database Monthly Electric Utility Sales and Revenue Data:* Data from 1994–2013 (Available at: *http://www.eia.doe.gov/cneaf/electricity/page/eia826.html*) (Last accessed October 15, 2015).

[59] U.S. Department of Energy-Energy Information Administration, *Natural Gas Navigator:* Data from1994–2013 (Available at: *http://tonto.eia.doe.gov/dnav/ng/ng_pri_sum_dcu_nus_m.htm*) (Last accessed October 15, 2015).

[60] U.S. Department of Energy-Energy Information Administration, *2013 State Energy Consumption, Price, and Expenditure Estimates (SEDS)* (Available at: *http://www.eia.doe.gov/emeu/states/_seds.html*) (Last accessed October 15, 2015).

[61] **Federal Register**: U.S. Department of Energy—Office of Energy Efficiency and Renewable Energy. Energy Conservation Program for Consumer Products: Energy Conservation Standards for Residential Furnaces; Notice of Proposed Rulemaking. **Federal Register**. March 12, 2015. vol. 80, no. 48.

[62] GTI provides a reference located in the docket of DOE's rulemaking to develop energy conservation standards for residential furnaces. (Docket No. EERE–2014–BT–STD–0031–0118) (Available at *http://www.regulations.gov/#!documentDetail;D=EERE-2014-BT-STD-0031-0118*). DOE is also including this information in the docket for the present rulemaking at *http://www.regulations.gov/#!documentDetail;D=EERE-2012-BT-STD-0047-0068.*

[63] RS Means Company Inc., *RS Means Facilities Maintenance & Repair Cost Data* (2013) (Available at: *http://www.rsmeans.com*).

consumer survey[64] that provided the frequency with which owners of different types of boilers perform maintenance. For oil-fired boilers, the high quantity of sulfur in the fuel in States without regulation of sulfur content results in frequent cleaning of the heat exchanger, which DOE included in its analysis.

For the final rule, DOE update the maintenance cost using the latest *2015 RS Means Facility Repair and Maintenance Data*.[65] In addition, DOE updated the list of States that require low-sulfur oil (15 PPM or less) for space heating to reflect regulations that will take effect by the compliance date of amended boiler standards (2021) based on data provided by Energy Kinetics. (Energy Kinetics, No. 52 at pp. 2–3)

The repair cost is the cost to the consumer for replacing or repairing components in the boiler that have failed (such as ignition, controls, gas valve, and inducer fan). For the NOPR, DOE estimated repair costs at each considered efficiency level using a variety of sources, including *2013 RS Means Facility Repair and Maintenance Data* and manufacturer literature. Higher repair costs for ignition, controls, gas valve, and inducer fan were included for condensing boilers. To determine components service lifetime, DOE used a Gas Research Institute (GRI) study.[66]

Crown Boiler questioned the applicability of the GRI data from the 1990s on the lifetimes of boiler parts because at that time, there were far fewer condensing boilers. (Crown Boiler, Public Meeting Transcript, No. 50 at p. 207) DOE understands that data from the GRI survey are still representative of the major furnace and boiler components. Further, due to improvements in the components of condensing boilers since the 1990s, the estimated service lifetime applied in DOE's analysis is likely conservative.

Based on typical contractor prices that Burnham collected from wholesalers for six non-condensing models and six condensing models, Burnham found that the cost to repair non-condensing boiler parts (*e.g.,* gas valve, blower, and controls) is significantly less than for condensing boilers. Furthermore, integrated controls for non-condensing boilers are on average significantly cheaper than a condensing boiler control. (Burnham, No. 60 at pp. 32–33) Weil-McLain stated that mechanical draft boilers would have higher repair costs due to the addition of draft inducers or blower motors, since there are more devices that will need adjustment, repair, and replacement, and the devices will need more frequent work. (Weil-McLain, No. 55 at p. 3) For the final rule, DOE updated its cost with the data provided by Burnham. For both the NOPR and final rule, DOE accounted for the additional repair cost associated with the draft inducers in boilers with mechanical draft.

For more details on DOE's methodology for calculating maintenance and repair costs, see appendix 8E of the final rule TSD.

6. Product Lifetime

Product lifetime is the age at which an appliance is retired from service. For the NOPR, DOE conducted an analysis of boiler lifetimes using a combination of historical boiler shipments (see section IV.G), American Housing Survey data on historical stock of boilers,[67] and RECS data[68] on the age of the boilers in homes. The data allowed DOE to develop a Weibull lifetime distribution function, which results in average and median lifetimes for the NOPR analysis of 25 years for all boiler product classes. In addition, DOE reviewed a number of sources to validate the derived boiler lifetime, including research studies (from the U.S. and Europe) and field data reports.[69]

U.S. Boiler, Crown Boiler, Energy Kinetic, Burnham, Lochinvar, and AHRI stated that condensing boilers generally have a shorter lifetime than non-condensing boilers. Lochinvar, Burnham, Energy Kinetics, and Crown Boiler stated that various sources cite condensing boilers as having a lifetime of 15 years or less. (US Boiler, Public Meeting Transcript, No. 50 at pp. 210–211; Crown Boiler, Public Meeting Transcript, No. 50 at p. 212; Energy Kinetic, No. 52 at p. 2; Burnham, No. 60 at pp. 33–36, pp. 54–55; Lochinvar, No. 63 at p. 4; AHRI, No. 64 at p. 4). Both Burnham and AHRI commented that their contractor surveys show a clear difference between condensing and non-condensing boiler lifetimes. (Burnham, No. 60 at pp. 35–36; AHRI, No. 66 at pp. 17–18) Burnham added that DOE's sources that are specific to condensing boilers[70][71] indicate the life expectancy of condensing boilers is approximately 15 years, which is significantly shorter than the life of non-condensing boilers (at least 23 years). Burnham stated that sources listed by DOE that pre-date 2003 (*i.e.,* around the time that the number of condensing boilers started to increase in the U.S.) cannot be used to estimate the life expectancy of condensing boilers. Burnham stated that references after 2003 should not be used either because statistically significant condensing boiler life expectancy data will take years to accumulate after these boilers were introduced into the U.S. market. Burnham also stated that a sample of manufacturers' warranties shows that condensing boilers have much shorter warranties than non-condensing boilers. (Burnham, No. 60 at pp. 33–36)

After carefully considering these comments, DOE has concluded that there is not enough data available to accurately distinguish the lifetime of condensing boilers because, as Burnham stated, they have not been prevalent in the U.S. market long enough to demonstrate whether their average lifetime is less than or greater than 15 years. In addition, condensing boiler technologies have been improving since their introduction to the U.S. market; therefore, the lifetime of the earliest condensing boilers may not be representative of current or future condensing boiler designs. Therefore, condensing lifetime results from the Burnham's and AHRI's contractor survey might be biased towards earliest condensing boiler designs and lack the number of condensing boilers installed 15 years or older. Based on the lack of clear and convincing information that condensing boilers have a shorter lifetime, DOE maintained the same

[64] Decision Analysts, *2008 American Home Comfort Study: Online Database Tool* (2009) (Available at: *http://www.decisionanalyst.com/Syndicated/HomeComfort.dai*).

[65] RS Means Company Inc., *RS Means Facilities Maintenance & Repair Cost Data* (2015) (Available at *http://www.rsmeans.com*).

[66] Jakob, F.E., J.J. Crisafulli, J.R. Menkedick, R.D. Fischer, D.B. Philips, R.L. Osbone, J.C. Cross, G.R. Whitacre, J.G. Murray, W.J. Sheppard, D.W. DeWirth, and W.H. Thrasher, *Assessment of Technology for Improving the Efficiency of Residential Gas Furnaces and Boilers, Volume I and II—Appendices* (September 1994) Gas Research Institute. Report No. GRI–94/0175 (Available at *http://www.gastechnology.org/reports_software/Pages/default.aspx*).

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

[68] U.S. Department of Energy: Energy Information Administration, *Residential Energy Consumption Survey Data, Multiple Years* (1987, 1990, 1993, 1997, 2002, 2005, and 2009) (Available at: *http://www.eia.gov/consumption/residential*) (Last accessed October, 2015).

[69] The sources used are listed in appendix 8F of the final rule TSD.

[70] Wohlfarth, R. *Boiler choices* (October 1, 2012) (Available at: *http://www.pmengineer.com/articles/90545-boiler-choices?v=preview*) (Last accessed October, 2015).

[71] Keman, R., M. van Elburg, W. Li, and R. van Holsteijn, *Preparatory Study on Eco-design of Boilers, Task 2 (Final) Market Analysis* (2007) (Available at: *http://www.ebpg.bam.de/de/ebpg_medien/001_studyf_07-11_part2.pdf*) (Last accessed October, 2015).

lifetime for condensing and non-condensing boilers. However, DOE did include additional repair costs for condensing boilers that would likely allow a similar lifetime as non-condensing boilers by assuming different service lifetimes for heat exchangers for condensing boilers and non-condensing boilers based on warranty data from product literature and survey data provided by stakeholders. DOE also conducted a sensitivity analysis using a different heat exchanger and boilers lifetime scenarios.

For the final rule, DOE updated its estimate of boiler lifetime by adding 2013 AHS data. In addition, DOE used the AHRI contractor survey data to derive separate lifetime estimates for different product classes. The data allowed DOE to develop a Weibull lifetime distribution function, which results in an average lifetimes of 26.5 for hot water gas-fired boilers, 23.6 for steam gas-fired boilers, 24.7 for hot water oil-fired boilers, and 19.2 for steam oil-fired boilers. For electric boilers, DOE assumed the same lifetime as gas-fired boilers. For more details on how DOE derived the boiler lifetime and on the lifetime sensitivity analysis, see appendix 8F of the final rule TSD.

7. Discount Rates

In the calculation of LCC, DOE applies discount rates appropriate to households to estimate the present value of future operating costs. DOE estimated a distribution of residential and commercial discount rates for residential boilers based on consumer financing costs and opportunity cost of funds related to appliance energy cost savings and maintenance costs.

To establish residential discount rates for the LCC analysis, DOE identified all relevant household debt or asset classes in order to approximate a consumer's opportunity cost of funds related to appliance energy cost savings. For the NOPR, it estimated the average percentage shares of the various types of debt and equity by household income group using data from the Federal Reserve Board's Survey of Consumer Finances [72] (SCF) for 1995, 1998, 2001, 2004, 2007, and 2010. Using the SCF and other sources, DOE developed a distribution of rates for each type of debt and asset by income group to represent the rates that may apply in the year in which amended standards would take effect. DOE assigned each sample household a specific discount rate drawn from one of the distributions. The average rate across all types of household debt and equity and income groups, weighted by the shares of each type that was used in the NOPR, was 4.5 percent.

To establish commercial discount rates for the LCC analysis, DOE estimated the weighted-average cost of capital using data from Damodaran Online.[73] The weighted-average cost of capital is commonly used to estimate the present value of cash flows to be derived from a typical company project or investment. Most companies use both debt and equity capital to fund investments, so their cost of capital is the weighted average of the cost to the firm of equity and debt financing. DOE estimated the cost of equity using the capital asset pricing model, which assumes that the cost of equity for a particular company is proportional to the systematic risk faced by that company.

EEI stated that it seems counterintuitive that the lowest income group has a lower discount rate than the higher income groups. (EEI, Public Meeting Transcript, No. 50 at p. 214) EEI stated that usually the lower income groups pay the highest interest rates for any sort of credit. (EEI, Public Meeting Transcript, No. 50 at p. 216) In DOE's analysis, the consumer discount rate is used to evaluate the present value of energy cost savings over the lifetime of the boiler. The interest rate on credit alone is not appropriate for this calculation. DOE instead calculates the residential discount rates by estimating the consumer's opportunity cost via a process analogous to the CAPM model used in the commercial sector, in which the discount rate is a weighted average of rates on debt and equity holdings. While consumers in the lowest income group are likely to face somewhat higher interest rates on credit than other income groups, this is balanced by the fact that they also tend to have assets with low interest rates (*e.g.,* larger share of assets in savings accounts or CDs, rather than stocks and mutual funds).

For the final rule, DOE included data from the 2013 SCF [74] to update the residential discount rates and updated Damodaran Online data [75] for commercial discount rates. See chapter 8 of the final rule TSD for further details on the development of consumer discount rates.

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

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

For the NOPR, DOE first developed data on the current share of residential boiler models in each product class that are of the different efficiencies based on the September 2013 AHRI certification directory,[76] ENERGY STAR shipments data,[77] and historical shipments data by efficiency from AHRI.[78] To estimate shares in 2020, DOE took into account the potential impacts of the ENERGY STAR program, which updated its performance criteria: 90-percent AFUE for gas-fired boilers and 87-percent AFUE for oil-fired boilers.[79] In addition, for gas-fired hot water boilers, DOE accounted for the regional differences in the market shares for condensing boilers using the historical shipments data by efficiency from AHRI.

Commenting on the NOPR, Burnham stated that over the past 12 years, since condensing boilers started to gain significant market share, the sales of gas-fired hot water boiler models with efficiencies between 85 percent and 90 percent have virtually disappeared, even though some models remain in the AHRI directory. (Burnham, No. 60 at p. 17) For the final rule, DOE modified its efficiency distribution in the no-new-

[72] The Federal Reserve Board, *Survey of Consumer Finances,* Multiple Years: 1989, 1992, 1995, 1998, 2001, 2004, 2007, 2010 (Available at: *http://www.federalreserve.gov/pubs/oss/oss2/scfindex.html*) (Last accessed October, 2015).

[73] Damodaran Online, *Data Page: Costs of Capital by Industry Sector* (2012) (Available at: *http://pages.stern.nyu.edu/~adamodar/*) (Last accessed October, 2015).

[74] The Federal Reserve Board, *Survey of Consumer Finances* (2013) (Available at: *http://www.federalreserve.gov/pubs/oss/oss2/scfindex.html*) (Last accessed October, 2015).

[75] Damodaran Online, *Data Page: Costs of Capital by Industry Sector* (2015) (Available at: *http://pages.stern.nyu.edu/~adamodar/*) (Last accessed October, 2015).

[76] Air Conditioning, Heating, and Refrigeration Institute, *Consumer's Directory of Certified Efficiency Ratings for Heating and Water Heating Equipment* (AHRI Directory) (September 2013) (Available at: *http://www.ahridirectory.org/ahridirectory/pages/home.aspx*) (Last accessed September 2013).

[77] ENERGY STAR, *Unit Shipments Data* (2003–2012) (Available at: *http://www.energystar.gov/index.cfm?c=partners.unit_shipment_data*) (Last accessed October 2015).

[78] Air-Conditioning Heating and Refrigeration Institute (AHRI), *2003–2012 Residential Boilers Shipments Data (Provided to Lawrence Berkeley National Laboratory)* (November 15, 2013).

[79] ENERGY STAR, *Boiler Specification Version 3.0.* (Available at: *https://www.energystar.gov/products/specs/boilers_specification_version_3_0_pd*) (Last accessed September 2013).

standards case in 2021 based on shipments data from Burnham (Burnham, No. 60 at pp. 18, 25), data from the AHRI contractor survey (AHRI, No. 66 at pp. 10–11), updated 2013 and 2014 ENERGY STAR unit shipment data for residential boilers,[80] and a dataset of models based on the 2015 AHRI certification directory.[81]

For the NOPR boiler standby mode and off mode standards analysis, DOE assumed that 50 percent of shipments would be at the baseline efficiency level and 50 percent would be at the max-tech efficiency level (EL 3) for all product classes, based on characteristics of available models.[82] For the final rule, DOE updated its estimated efficiency distribution in the no-new-standards case in 2021 based on DOE's test data and data provided by Burnham. (Burnham, No. 60 at p. 21)

The estimated AFUE market shares for the no-new-standards case for residential boilers are shown in Table IV.25, and estimated standby mode and off mode market shares for the no-new-standards case are shown in Table IV.26.[83] See chapter 8 of the final rule TSD for further information on the derivation of the efficiency distributions.

TABLE IV.25—EFFICIENCY DISTRIBUTION IN THE NO-NEW-STANDARDS CASE FOR RESIDENTIAL BOILERS FOR AFUE STANDARDS

EL	Design option	2021 market share (%)
Gas-fired Hot Water Boiler		
0	82% AFUE—Baseline	22.8
1	83% AFUE—Increased HX Area	7.6
2	84% AFUE—Increased HX Area	11.3
3	85% AFUE—Increased HX Area	4.6
4	90% AFUE—Condensing Baseline	11.2
5	92% AFUE—Increased HX Area	41.3
6	96% AFUE—Max-Tech	1.2
Gas-fired Steam Boiler		
0	80% AFUE—Baseline	16.8
1	82% AFUE—Increased HX Area	71.6
2	83% AFUE—Max-Tech	11.6
Oil-fired Hot Water Boiler		
0	84% AFUE—Baseline	44.5
1	85% AFUE—Increased HX Area	18.4
2	86% AFUE—Increased HX Area	33.2
3	91% AFUE—Max-Tech	3.9
Oil-fired Steam Boiler		
0	82% AFUE—Baseline	44.9
1	84% AFUE—Increased HX Area	28.7
2	85% AFUE—Increased HX Area	18.9
3	86% AFUE—Max-Tech	7.6

TABLE IV.26—EFFICIENCY DISTRIBUTION IN THE NO-NEW-STANDARDS CASE FOR RESIDENTIAL BOILERS FOR STANDBY/OFF MODE STANDARDS

EL	Power (W)	Design option	2021 market share (%)
Gas-fired Hot Water Boiler			
0	11.5	Linear Power Supply *	3.0
1	10.0	Linear Power Supply with Low-Loss Transformer (LLTX)	3.0
2	9.7	Switching Mode Power Supply **	3.0
3	9.0	Max-Tech—Switching Mode Power Supply with LLTX	91.0
Gas-fired Steam Boiler			
0	10.5	Linear Power Supply *	1.0

[80] ENERGY STAR, *Unit Shipments* (2013–2014) (Available at: *http://www.energystar.gov/index.cfm?c=partners.unit_shipment_data*) (Last accessed October 2015).

[81] Air Conditioning, Heating, and Refrigeration Institute, Consumer's Directory of Certified Efficiency Ratings for Heating and Water Heating Equipment (AHRI Directory) (August 2015) (Available at: *http://www.ahridirectory.org/ahridirectory/pages/home.aspx*) (Last accessed October 19, 2015).

[82] Air Conditioning, Heating, and Refrigeration Institute, *Consumer's Directory of Certified Efficiency Ratings for Heating and Water Heating Equipment (AHRI Directory)* (September 2013) (Available at: *http://www.ahridirectory.org/ahridirectory/pages/home.aspx*) (Last accessed September 2013).

[83] As discussed in section IV.C.1, because DOE's review of product literature and discussions with manufacturers revealed that most boilers do not have seasonal off switches, DOE assumed that the standby mode and the off mode power consumption are equal for its analysis.

TABLE IV.26—EFFICIENCY DISTRIBUTION IN THE NO-NEW-STANDARDS CASE FOR RESIDENTIAL BOILERS FOR STANDBY/OFF MODE STANDARDS—Continued

EL	Power (W)	Design option	2021 market share (%)
1	9.0	Linear Power Supply with Low-Loss Transformer (LLTX)	1.0
3	8.7	Switching Mode Power Supply **	1.0
3	8.0	Max-Tech—Switching Mode Power Supply with LLTX	97.0
Oil-fired Hot Water Boiler			
0	13.5	Linear Power Supply *	3.0
1	12.0	Linear Power Supply with Low-Loss Transformer (LLTX)	3.0
2	11.7	Switching Mode Power Supply **	3.0
3	11.0	Max-Tech—Switching Mode Power Supply with LLTX	91.0
Oil-fired Steam Boiler			
0	13.5	Linear Power Supply *	1.0
1	12.0	Linear Power Supply with Low-Loss Transformer (LLTX)	1.0
2	11.7	Switching Mode Power Supply **	1.0
3	11.0	Max-Tech—Switching Mode Power Supply with LLTX	97.0
Electric Hot Water Boiler			
0	10.5	Linear Power Supply *	1.0
1	9.0	Linear Power Supply with Low-Loss Transformer (LLTX)	1.0
2	8.7	Switching Mode Power Supply **	1.0
3	8.0	Max-Tech—Switching Mode Power Supply with LLTX	97.0
Electric Steam Boiler			
0	10.5	Linear Power Supply *	1.0
1	9.0	Linear Power Supply with Low-Loss Transformer (LLTX)	1.0
2	8.7	Switching Mode Power Supply **	1.0
3	8.0	Max-Tech—Switching Mode Power Supply with LLTX	97.0

* A linear power supply regulates voltage with a series element.
** A switching mode power supply regulates voltage with power handling electronics.

9. Payback Period Analysis

The payback period is the amount of time it takes the consumer to recover the additional installed cost of more-efficient products, compared to baseline products, through energy cost savings. Payback periods are expressed in years. Payback periods that exceed the life of the product mean that the increased total installed cost is not recovered in reduced operating expenses.[84]

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

As noted above, EPCA, as amended, establishes a rebuttable presumption that a standard is economically justified if the Secretary finds that the additional cost to the consumer of purchasing a product complying with an energy conservation standard level will be less than three times the value of the first year's energy savings resulting from the standard, as calculated under the applicable test procedure. (42 U.S.C. 6295(o)(2)(B)(iii)) For each considered efficiency level, DOE determined the value of the first year's energy savings by calculating the energy savings in accordance with the applicable DOE test procedure, and multiplying those savings by the average energy price forecast for the year in which compliance with the amended standards would be required. However, DOE's LCC and PBP analyses generate values that calculate the payback period for consumers under potential energy conservation standards, which includes, but is not limited to, the three-year payback period contemplated under the rebuttable presumption test. 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. 6295(o)(2)(B)(i). 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).

G. Shipments Analysis

DOE uses forecasts of annual product shipments to calculate the national impacts of potential amended energy conservation standards on energy use, NPV, and future manufacturer cash flows.[85] DOE develops shipment projections based on historical data and an analysis of key market drivers for each product. DOE estimated boiler shipments by projecting shipments in three market segments: (1) Replacements; (2) new housing/buildings; and (3) new owners in buildings that did not previously have a boiler.[86] DOE also considered the

[84] The ENERGY STAR specification for residential boilers was revised in October 2015 to 90-percent AFUE for gas boilers and 87-percent AFUE for oil boilers.

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

[86] The new owners consists of both households that during a major remodel add or switch to hydronic heating, as well as, households switching between different boiler product classes.

impact of standards that require more-efficient boilers on boiler shipments.

For the NOPR, to project boiler replacement shipments, DOE developed retirement functions based on the boiler lifetime estimates used in the LCC analysis and applied them to the existing products in the building stock. The existing stock of products is tracked by vintage and developed from historical shipments data.[87] [88] The shipments model for replacements uses a distribution of residential boiler lifetimes to estimate boiler replacement shipments, and it also accounts for the fraction of residential boiler units that were installed in demolished buildings. As the demolished units do not need to be replaced, they are deducted when calculating the required replacements.

For the NOPR, to project shipments to the new housing market, DOE utilized a forecast of new housing or building construction and historic saturation rates of various boiler product types in new housing or building construction. DOE used *AEO 2013* for forecasts of new housing. Boiler saturation rates in new housing were estimated based on a weighted-average of values in 1990–2013 presented in the U.S. Census Bureau's *Characteristics of New Housing,*[89] as well as RECS 2009 and CBECS 2003 data.

For the NOPR, to estimate future shipments to new owners, DOE based its estimates on market trends and historical shipment data from 2008 to 2012. The new owners primarily consist of households that during a major remodel add hydronic heating using a gas-fired hot water boiler and households that choose to install a boiler with a hydronic air handler to replace a gas furnace. New owners also include households switching between different boiler product classes (*i.e.,* from the steam to hot water boiler product classes and from the oil-fired to gas-fired boiler product classes).

Commenting on the NOPR, ACCA stated that, based on feedback from a select number of ACCA members, the percentage of gas-fired boiler installations associated with new construction falls within DOE's range (*i.e.,* 90 percent replacements and 10 percent new construction). For oil-fired hot water boilers, the breakdown of 98 percent replacements and 2 percent new construction is also in line with ACCA's field experience. (ACCA, No. 65 at p. 2) Weil-McLain stated that approximately 90 percent of boiler sales in the U.S. are to the replacement market. (Weil-McLain, No. 55 at pp. 1–2) These comments align with the fractions of boiler shipments both for the NOPR and final rule analysis. For the final rule, DOE refined its analysis by including updated historical shipment data [90] and data from *AEO 2015.*

The NOPR analysis accounted for the impact of increased product price for the considered efficiency levels on shipments by incorporating relative price elasticity in the shipments model. This approach gives some weight to the operating cost savings from higher-efficiency products. In general, price elasticity reflects the expectation that demand will decrease when prices increase. The price elasticity value is derived from data on refrigerators, clothes washers, and dishwashers.[91] To model the impact of the increase in relative price from a particular standard level on residential boiler shipments, DOE assumed that the shipments that do not occur represent consumers that would repair their product rather than replace it, extending the life of the product by 6 years.

AHRI stated that the price elasticity data used for DOE's analysis is not a good match for boilers because consumers look for different attributes, such as appearance or special functions, when buying refrigerators and clothes washers, whereas with boilers, the same considerations do not apply. (AHRI, Public Meeting Transcript, No. 50 at pp. 239–240) AHRI stated that DOE has a responsibility to explain why a price analysis for washing machines and refrigerators is an acceptable substitute for residential boilers. (AHRI, No. 64 at p. 5)

In response, DOE first notes that there are very few estimates of consumer demand elasticity for durable goods. For the final rule, DOE updated its price elasticity to a value calculated from price, shipments, and efficiency data over 1989–2009 for five common residential appliances (clothes washers, refrigerators, freezers, dishwashers, and room air conditioners).[92] DOE reasons that this cross-section of residential appliances provides a representative price elasticity and response of shipments to efficiency for residential consumers. The one study of price elasticity for a residential HVAC product, found in an extensive literature review, provides an estimated value (−0.24) that is less elastic than the value used by DOE in the final rule analysis (−0.45). DOE did not apply this value, however, because the long-run elasticity estimate of −0.24 is consistent with DOE's residential price elasticity and elasticity time trend, which starts with an elasticity of −0.45 in the first year following a price increase, decreasing to approximately −0.2 by the fifth year following a price increase.

Weil-McLain stated that a homeowner will often decide to repair their existing boiler and delay replacement if the total installed cost is too great. (Weil-McLain, No. 55 at p. 6) Burnham stated that *de facto* outlawing of Category I replacement cast iron boilers will result in some (particularly low-income) homeowners delaying the replacement of existing low-efficiency, decades-old boilers with newer and higher efficiency models. (Burnham, No. 60 at p. 17) PGW stated that the additional costs associated with the installation of near-condensing boilers in row houses are likely to delay the installation of higher-efficiency boilers, extend the use of existing boilers beyond their safe operating life, drive switching to alternative heating systems that may well be less safe and/or economical than currently installed boilers, or some combination of all these outcomes. (PGW, No. 57 at p. 2)

In response, at the higher efficiency levels where installed cost is much higher than the boiler in the no-new-standards case, DOE accounts for repair of old boilers to extend their lifetime through the price elasticity parameters described above. This parameter relates the repair decision to the incremental installed cost and the operating cost savings of higher-efficiency boilers, both of which have some weight in the consumer decision. DOE estimated that the average extension of life of the repaired unit would be six years, and then that unit is replaced with a new boiler. In the NIA, the cost of the repair and the energy costs of the repaired unit are accounted for.

[87] Appliance Magazine, *U.S. Appliance Industry Statistical Review,* Multiple years: 1970, 1979, 1987, 2000, 2009.

[88] Air-Conditioning Heating and Refrigeration Institute (AHRI), *2003–2012 Residential Boilers Shipments Data (Provided to Lawrence Berkeley National Laboratory)* (November 15, 2013).

[89] U. S. Department of Commerce—Bureau of the Census, *Characteristics of New Housing* (1990–2013) (Available at: *http://www.census.gov/const/www/charindex.html*) (Last accessed March 15, 2013).

[90] Appliance Magazine, *Appliance Historical Statistical Review: 1954–2012* (2014).

[91] Dale, L. and S. K. Fujita, *An Analysis of the Price Elasticity of Demand of Household Appliances* (2008) Lawrence Berkeley National Laboratory (Report No. LBNL–326E) (Available at: *http://eetd.lbl.gov/sites/all/files/lbnl-326e.pdf*) (Last accessed: October 2015).

[92] Fujita, S. K., *Estimating Price Elasticity using Market-Level Appliance Data* (2015) Lawrence Berkeley National Laboratory (Report No. LBNL–188289) (Available at: *https://eaei.lbl.gov/sites/all/files/lbnl-188289.pdf*) (Last accessed: October 2015).

For the NOPR and final rule, DOE evaluated the potential for switching from gas-fired and oil-fired hot water boilers to other heating systems in response to amended standards. The main alternative to hot water boilers would be installation of an electric boiler, a forced-air furnace, heat pump, or a mini-split heat pump. These alternatives would require significant installation costs such as adding ductwork or an electrical upgrade, and an electric boiler would have very high relative energy costs. Given that the increase in installed cost of boilers meeting the amended standards, relative to the no-new-standards case, is small, DOE has concluded that consumer switching from hot water boilers would be rare.

The details and results of the shipments analysis can be found in chapter 9 of the final rule TSD.

H. National Impact Analysis

The NIA assesses the national energy savings (NES) and the national net present value (NPV) from a national perspective of total consumer costs and savings expected to result from new or amended energy conservation standards at specific efficiency levels. (''Consumer'' in this context refers to consumers of the product being regulated.) DOE calculates the NES and NPV for the potential standard levels considered for the residential boiler product classes analyzed based on projections of annual product shipments, along with the annual energy consumption and total installed cost data from the energy use and LCC analyses. For the NOPR analysis, DOE forecasted the energy savings, operating cost savings, product costs, and NPV of consumer benefits over the lifetime of residential boilers sold from 2020 through 2049. For the final rule analysis, DOE performed the same analyses over the lifetime of residential boilers sold from 2021 through 2050.

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

DOE uses a spreadsheet model to calculate the energy savings and the national consumer costs and savings from each TSL. Interested parties can review DOE's analyses by changing various input quantities within the spreadsheet. The NIA spreadsheet model uses typical values (as opposed to probability distributions) as inputs. To assess the effect of input uncertainty on NES and NPV results, DOE developed its spreadsheet model to conduct sensitivity analyses by scenarios on specific input variables. In the NIA, DOE forecasted the lifetime energy savings, energy cost savings, product costs, and NPV of consumer benefit for each product class over the lifetime of products sold from 2021 through 2050.

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

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

Inputs	Method
Shipments	Annual shipments from shipments model.
Compliance Date of Standard	2021.
Efficiency Trends	Based on historical trends of shipments by efficiency and updated ENERGY STAR criteria.
Annual Energy Consumption per Unit	Annual weighted-average values are a function of energy use at each TSL.
Total Installed Cost per Unit	Annual weighted-average values are a function of cost at each TSL. Projects constant future product prices based on historical data.
Annual Energy Cost per Unit	Annual weighted-average values as a function of the annual energy consumption per unit and energy prices.
Rebound Effect	Applied a rebound effect value dependent on application and sector.
Repair and Maintenance Cost per Unit	Annual values do not change with efficiency level.
Energy Prices	*AEO 2015* forecasts (to 2040) and extrapolation through 2050.
Energy Site-to-Primary and FFC Conversion	A time-series conversion factor based on *AEO 2015*.
Discount Rate	Three and seven percent.
Present Year	2015.

1. Product Efficiency Trends

A key component of the NIA is the trend in energy efficiency projected for the no-new-standards case and each of the standards cases. Section IV.F of this notice describes how DOE developed an energy efficiency distribution for the no-new-standards case (which yields a shipment-weighted average efficiency) for each of the considered residential boiler product classes for the first year of the forecast period (*i.e.,* the year of anticipated compliance with an amended standard).

For the NOPR, regarding the efficiency trend in the years after compliance, for the no-new-standards case, DOE estimated that the overall market share of condensing gas-fired hot water boilers would grow from 44 percent to 63 percent by 2049, and the overall market share of condensing oil-fired hot water boilers would grow from 7 percent to 13 percent. DOE estimated that the no-new-standards case market shares of condensing gas-fired and oil-fired steam boilers will be negligible during the period of analysis. DOE assumed similar trends for the standards cases (albeit starting from a higher point).

For the final rule, DOE modified its efficiency trend in the no-new-standards case in 2021, as described in section IV.F. Based on this updated data, DOE estimated that the overall market share of condensing gas-fired hot water boilers would grow from 54 percent in 2021 to 74 percent by 2050, and the overall market share of condensing oil-fired hot water boilers would grow from 4 percent to 8 percent. The no-new-standards case market shares of condensing gas-fired and oil-fired steam boilers remain negligible. Details on how these efficiency trends were developed are provided in appendix 8H of the final rule TSD.

For the NOPR and final rule boiler standby mode and off mode standard analysis, DOE assumed that the efficiency level distributions would remain constant over the analysis period.

For the NOPR and final rule, for the standards cases, DOE used a ''roll-up'' scenario to establish the shipment-weighted efficiency for the year that standards are assumed to become effective. In this scenario, the market of products in the no-new-standards case that do not meet the standard under consideration would ''roll up'' to meet the new standard level, and the market share of products above the standard would remain unchanged.

Burnham stated that if DOE were to adopt the 85-percent level for gas-fired hot water boilers, most of the gas-fired hot water boiler sales would move to the condensing level due to the very limited ability to use Category I venting, combined with the cost of AL29-4C stainless steel generally required at near-condensing (85 to 89 percent) efficiencies. (Burnham, No. 60 at p. 16) AGA agreed that a certain percentage of the market will be forced to the condensing level with an 85-percent standard, which could incur a net cost for consumers. (AGA, Public Meeting Transcript, No. 50 at pp. 289–290)

In the current analysis, on average, going to 85-percent AFUE has a lower total installed cost than going to the condensing level (*i.e.,* 90-percent AFUE and above). DOE agrees there might be some switching for a small fraction of consumers that have high installation costs at 85-percent AFUE, but since DOE is not adopting an 85-percent AFUE standard, DOE did not assess this for the final rule. DOE notes that this final rule adopts an 84-percent AFUE level for gas-fired hot water boilers. From 82- to 84-percent AFUE, the installation cost is the same, and the equipment cost is similar, whereas at 85-percent AFUE, there is a large increase in installation costs for a fraction of replacement installations requiring new stainless steel venting for households replacing an 82- to 84-percent AFUE boiler with an 85-percent AFUE boiler. Therefore, DOE has determined that a consumer would be more likely to choose to switch to a condensing boiler if the standard were at 85-percent AFUE (as proposed in the NOPR) than at 84-percent (as is being adopted by this final rule). Thus, DOE has substantially lessened the likelihood of consumers being forced to install condensing equipment by adopting an 84-percent AFUE standard for gas-fired hot water boilers.

2. National Energy Savings

The national energy savings analysis involves a comparison of national energy consumption of the considered products between each potential standards case (TSL) and the case with no new or amended energy conservation standards. DOE calculated the national energy consumption by multiplying the number of units (stock) of each product (by vintage or age) by the unit energy consumption (also by vintage). Vintage represents the age of the product. DOE calculated annual NES based on the difference in national energy consumption for the case without amended efficiency standards and for each higher efficiency standard. For the NOPR, DOE estimated energy consumption and savings based on site energy and converted the electricity consumption and savings to primary energy using annual conversion factors derived from the *AEO 2013* version of NEMS. For the final rule, DOE used conversion factors derived from *AEO 2015.* Cumulative energy savings are the sum of the NES for each year over the timeframe of the analysis.

DOE considered whether boiler energy use would likely be impacted by a direct rebound effect, which occurs when a product that is made more efficient is used more intensively, such that the expected energy savings from the efficiency improvement may not fully materialize. For the NOPR, after reviewing several studies on the direct rebound effect, DOE included a 15-percent rebound effect for residential boilers due to an AFUE standard. For the final rule, DOE updated the rebound effect value to range from 9 to 11 percent depending on the product class, taking into account differences in the rebound effect associated with space heating and water heating energy use, as well as residential and commercial applications based on a review of the studies on the direct rebound effect. In both the NOPR and final rule, DOE did not consider a rebound effect for standby mode and off mode standards, because consumers typically have no awareness of any efficiency change in standby mode and off mode. See chapter 10 of the final rule TSD for DOE's assessments of rebound effect literature.

In 2011, in response to the recommendations of a committee on ''Point-of-Use and Full-Fuel-Cycle Measurement Approaches to Energy Efficiency Standards'' appointed by the National Academy of Sciences, DOE announced its intention to use 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). After evaluating 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 EIA's National Energy Modeling System (NEMS) is the most appropriate tool for its full-fuel-cycle (FFC) analysis and its intention to use NEMS for that purpose. 77 FR 49701 (August 17, 2012). NEMS is a public domain, multi-sector, partial equilibrium model of the U.S. energy sector [93] that EIA uses to prepare its *Annual Energy Outlook.*

NPGA stated that it is not clear in the NOPR that DOE applied the FFC evaluation to the entire energy path of electric-powered residential boilers. NPGA requested that the agency apply to electric-powered residential boilers the same FFC analysis utilized to assess primary fuels. NPGA requested that DOE clarify the extent to which electric-powered residential boilers were evaluated through the FFC analysis. (NPGA, No. 53, pp. 1–3)

In response, DOE did not analyze electric boilers for AFUE standards because their efficiency is close to 100-percent AFUE. However, DOE did analyze electric boilers for the standby mode and off mode standards, and applied the FFC analysis, including power plant and upstream energy use, to electric boilers as well as gas-fired and oil-fired boilers.

The approach used for deriving FFC measures of energy use and emissions is described in appendix 10B of the final rule TSD.

3. Net Present Value Analysis

The inputs for determining NPV are: (1) Total annual installed cost; (2) total annual savings in operating costs; (3) a discount factor to calculate the present value of costs and savings; (4) present value of costs; and (5) present value of savings. DOE calculated net savings each year as the difference between the no-new-standards case and each standards case in terms of total savings in operating costs versus total increases in installed costs. DOE calculated savings over the lifetime of products shipped in the forecast period. DOE calculated NPV as the difference between the present value of operating cost savings and the present value of total installed costs.

[93] For more information on NEMS, refer to *The National Energy Modeling System: An Overview,* DOE/EIA–0581 (October 2009) (Available at: *http://www.eia.gov/*).

a. Total Annual Installed Cost

For the NPV analysis, DOE calculates increases in total installed costs as the difference in total installed cost between the no-new-standards case and standards cases (*i.e.,* once the new or amended standards take effect). For the NOPR and final rule, as discussed in section IV.F.1of this notice, DOE assumed a constant residential boiler price trend. DOE applied the same trend to forecast prices for each product class at each considered efficiency level. DOE's projection of product prices is described in appendix 10C of the final rule TSD.

To evaluate the effect of uncertainty regarding the price trend estimates, DOE investigated the impact of different product price forecasts on the consumer NPV for the considered TSLs for residential boilers. In addition to the default price trend, DOE considered two product price sensitivity cases: (1) A high price decline case based on 1980–1998 PPI data; and (2) a low price decline case based on *AEO 2015* data. The derivation of these price trends and the results of these sensitivity cases are described in appendix 10C of the final rule TSD.

b. Total Annual Operating Cost Savings

Operating cost savings are estimated by comparing total energy expenditures and repair and maintenance costs for the no-new-standards case and the standards cases. Total savings in operating costs are the product of savings per unit and the number of units of each vintage that survive in a given year. DOE calculates annual energy expenditures from annual energy consumption by incorporating forecasted energy prices. To calculate future energy prices, DOE applied the projected trend in national-average commercial energy prices from the *AEO 2015* Reference case (which extends to 2040) to the recent prices derived in the LCC and PBP analysis. DOE used the trend from 2030 to 2040 to extrapolate beyond 2040. As part of the NIA, DOE also analyzed scenarios that used inputs from the *AEO 2015* Low Economic Growth and High Economic Growth cases. Those cases have higher and lower energy price trends compared to the Reference case. NIA results based on these cases are presented in appendix 10C of the final rule TSD.

c. Net Benefit

The aggregate difference each year between operating cost savings and increased equipment expenditures is the net savings or net costs. In calculating the NPV, DOE multiplies the net savings in future years by a discount factor to determine their present value. For this final rule, DOE estimated the NPV of consumer benefits using both a 3-percent and a 7-percent real discount rate. DOE uses these discount rates in accordance with guidance provided by the Office of Management and Budget (OMB) to Federal agencies on the development of regulatory analysis.[94] The discount rates for the determination of NPV are in contrast to the discount rates used in the LCC analysis, which are designed to reflect a consumer's perspective. The 7-percent real value is an estimate of the average before-tax rate of return to private capital in the U.S. economy. The 3-percent real value represents the ''social rate of time preference,'' which is the rate at which society discounts future consumption flows to their present value.

I. Consumer Subgroup Analysis

In analyzing the potential impact of new or amended energy conservation standards on consumers, DOE evaluates the impact on identifiable subgroups of consumers that comprise a subset of the population that may be disproportionately affected by a new or amended national standard (*e.g.,* low-income consumers, seniors). The purpose of a subgroup analysis is to determine the extent of any such disproportional impacts. DOE evaluates impacts on particular subgroups of consumers by analyzing the LCC impacts and PBP for those particular consumers from alternative standard levels.

For the NOPR and final rule, DOE analyzed the impacts of the considered standard levels on two subgroups: (1) Low-income households and (2) senior-only households. DOE identified these households in the RECS 2009 sample and used the LCC and PBP spreadsheet model to estimate the impacts of the considered efficiency levels on these subgroups. To the extent possible, it utilized inputs appropriate for these subgroups.

The consumer subgroup results for the residential boilers TSLs are presented in section V.B.1.b of this notice and chapter 11 of the final rule TSD.

J. Manufacturer Impact Analysis

1. Overview

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

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

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

DOE conducted the MIA for this rulemaking in three phases. In the first phase of the MIA, DOE prepared a profile of the residential boiler

[94] United States Office of Management and Budget, OMB Circular A–4: Regulatory Analysis (Sept. 17, 2003) section E, ''Identifying and Measuring Benefits and Costs'' (Available at: *http://www.whitehouse.gov/omb/memoranda/m03-21.html*).

manufacturing industry based on the market and technology assessment, preliminary manufacturer interviews, and publicly-available information. As part of its profile of the residential boilers industry, DOE also conducted a top-down cost analysis of residential boiler manufacturers that DOE used to derive preliminary financial inputs for the GRIM (*e.g.,* revenues; materials, labor, overhead, and depreciation expenses; selling, general, and administrative expenses (SG&A); tax rates, and R&D expenses). DOE also used public sources of information to further calibrate its initial characterization of the residential boiler manufacturing industry, including company filings of form 10–K from the SEC,[95] corporate annual reports, the U.S. Census Bureau's *Economic Census,*[96] and reports from Hoover's.[97]

In second phase of the MIA, DOE prepared an industry cash-flow analysis to quantify the potential impacts of new and amended energy conservation standards. The GRIM uses several factors to determine a series of annual cash flows starting with the announcement of the standard and extending over a 30-year period following the compliance date of the standard. These factors include annual expected revenues, costs of sales, SG&A and R&D expenses, taxes, and capital expenditures. In general, energy conservation standards can affect manufacturer cash flow in three distinct ways: (1) Creating a need for increased investment; (2) raising production costs per unit; and (3) altering revenue due to higher per-unit prices and changes in sales volumes. 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. The GRIM modeled both impacts from the AFUE energy conservation standards and impacts from standby mode and off mode energy conservation standards (*i.e.,* standards based on standby mode and off mode wattage). The GRIM results from the two standards were evaluated independent of one another.

In addition, during the second phase of the MIA, DOE developed interview guides to distribute to manufacturers of residential boilers in order to develop other key GRIM inputs, including product and capital conversion costs, and to gather additional information on the anticipated effects of energy conservation standards on revenues, direct employment, capital assets, industry competitiveness, and subgroup impacts.

In the third phase of the MIA, DOE conducted structured, detailed interviews with a variety of manufacturers that represent approximately 46 percent of domestic residential boiler sales covered by this rulemaking. During these interviews, DOE discussed engineering, manufacturing, procurement, and financial topics to validate assumptions used in the GRIM and to identify key issues or concerns. See section IV.J.4 for a description of the key issues raised by manufacturers during the interviews.

Additionally, in the third phase, DOE also evaluated subgroups of manufacturers that may be disproportionately impacted by amended standards or that may not be accurately represented by the average cost assumptions used to develop the industry cash-flow analysis. For example, small manufacturers, niche players, or manufacturers exhibiting a cost structure that largely 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 65 FR 53533, 53544 (Sept. 5, 2000) and codified at 13 CFR part 121. To be categorized as a small business under North American Industry Classification System (NAICS) code 333414, ''Heating Equipment (except Warm Air Furnaces) Manufacturing,'' a residential boiler manufacturer and its affiliates may employ a maximum of 500 employees. The 500-employee threshold includes all employees in a business's parent company and any other subsidiaries. Based on this classification, DOE identified at least 13 residential boiler companies that qualify as small businesses.

The residential boiler small manufacturer subgroup is discussed in section VI.B of this final rule and in chapter 12 of the final rule TSD.

2. Government Regulatory Impact Model

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 was designed 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 2014 (the base year of the analysis) and continuing to 2050. DOE summed the stream of annual discounted cash flows during this period to calculate INPVs at each TSL. For residential boiler manufacturers, DOE used a real discount rate of 8.0 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 final rule TSD.

For consideration of standby mode and off mode regulations, DOE modeled the impacts of the technology options for reducing electricity usage discussed in the engineering analysis (chapter 5 of the final rule TSD). The GRIM analysis incorporates the incremental additions to the MPC of standby mode and off mode features and the resulting impacts on markups.

Due to the small cost of standby mode and off mode components relative to the overall cost of a residential boiler, DOE assumes that standards regarding standby mode and off mode features alone would not impact product shipment numbers. Additionally, DOE has concluded that the incremental cost

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

[96] 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*).

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

of standby mode and off mode features would not have a differentiated impact on manufacturers of different product classes. Consequently, DOE models the impact of standby mode and off mode for the industry as a whole.

The electric boiler product classes were not analyzed in the GRIM for AFUE energy conservation standards. As a result, quantitative numbers for those product classes are not available in the GRIM analyzing standby mode and off mode standards. However, the standby mode and off mode technology options considered for electric boilers are identical to the technology options for all other residential boiler product classes. As a result, DOE expects the standby mode and off mode impacts on electric boilers to be of the same order of magnitude as the impacts on all other residential boiler product classes.

a. Government Regulatory Impact Model Key Inputs

Manufacturer Production Costs

Manufacturing a higher-efficiency product is typically more expensive than manufacturing a baseline product due to the use of more complex components, which are typically more costly than baseline components. The changes in the MPCs of the analyzed products can affect the revenues, gross margins, and cash flow of the industry, making these product cost data 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 final rule TSD. In addition, DOE used information from its teardown analysis (described in chapter 5 of the final rule TSD) to disaggregate the MPCs into material, labor, and overhead costs. To calculate the MPCs for products at and above the baseline, DOE performed teardowns and cost modeling that allowed DOE to estimate the incremental material, labor, and overhead costs for products above the baseline. These cost breakdowns and product 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 2014 (the base year) to 2050 (the end year of the analysis period). The shipments model divides the shipments of residential boilers 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 product stock, broken down by age or vintage, in each year of the analysis period. In addition, the product stock efficiency distribution is calculated for the base case and for each standards case for each product class. The NIA shipments forecasts are, in part, based on a roll-up scenario. The forecast assumes that a product in the base case that does not meet the standard under consideration would "roll up" to meet the amended standard beginning in the compliance year of 2021. See section IV.G and chapter 9 of the final rule TSD for additional details.

Product and Capital Conversion Costs

Amended energy conservation standards would cause manufacturers to incur one-time conversion costs to bring their production facilities and product designs into compliance. DOE evaluated the level of conversion-related expenditures that would be needed to comply with each considered efficiency level in each product class. For the MIA, DOE classified these conversion costs into two major groups: (1) 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 product 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 product designs comply with amended energy conservation standards.

To evaluate the level of capital conversion expenditures manufacturers would likely incur to comply with amended energy conservation standards, DOE used manufacturer interviews to gather data on the anticipated level of capital investment that would be required at each efficiency level. Based on manufacturer feedback, DOE developed a market-share-weighted manufacturer average capital expenditure which it then applied to the entire industry. DOE also made assumptions about which manufacturers would develop their own condensing heat exchanger production lines, in the event that efficiency levels using condensing technology were proposed. DOE supplemented manufacturer comments and tailored its analyses with estimates of capital expenditure requirements derived from the product teardown analysis and engineering analysis described in chapter 5 of the final rule TSD.

DOE assessed the product conversion costs at each considered efficiency level by integrating data from quantitative and qualitative sources. DOE considered market-share-weighted feedback regarding the potential costs of each efficiency level from multiple manufacturers to estimate product conversion costs (*e.g.,* R&D expenditures, certification costs) and validated those numbers against engineering estimates of redesign efforts. DOE combined this information with product listings to estimate how much manufacturers would have to spend on product development and product testing at each efficiency level. Manufacturer data were aggregated to better reflect the industry as a whole and to protect confidential information.

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.a of this notice. For additional information on the estimated product and capital conversion costs, see chapter 12 of the final rule 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, and overhead estimated in DOE's MPCs) and all non-production costs (*i.e.,* SG&A, R&D, and interest), along with profit. To calculate the MSPs in the GRIM, DOE applied non-production cost markups to the MPCs estimated in the engineering analysis for each product class and efficiency level. Modifying these 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 a product class. As production costs increase with efficiency, this scenario implies that the absolute dollar markup will increase as well. Based on publicly-available financial information for manufacturers of residential boilers, as well as comments from manufacturer interviews, DOE assumed the average non-production cost markup—which includes SG&A expenses, R&D expenses, interest, and profit—to be 1.41 for all product classes. This markup scenario represents the upper bound of the residential boiler industry's profitability in the standards case because manufacturers are able to fully pass through additional costs due to standards to consumers.

DOE decided to include the preservation of per-unit operating profit scenario in its analysis 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 residential boiler 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 base 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 base case. Therefore, operating margin in percentage terms is reduced between the base case and standards case. DOE adjusted the manufacturer markups in the GRIM at each TSL to yield approximately the same earnings before interest and taxes in the standards case as in the base 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 consumers the additional costs necessitated by residential boiler standards, as they are able to do in the preservation of gross margin percentage markup scenario.

3. Manufacturer Interviews

DOE interviewed manufacturers representing approximately 55 percent of the residential boiler 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 residential boilers market. These interviews were in addition to those DOE conducted as part of the engineering analysis. The information gathered during these interviews enabled DOE to tailor the GRIM to reflect the unique financial characteristics of the residential boiler industry. The information gathered during these interviews enabled DOE to tailor the GRIM to reflect the unique financial characteristics of the residential boiler 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 residential boilers. 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. Manufacturers raised a range of general issues for DOE to consider, including a diminished ability to serve the replacement market, concerns that condensing boilers may not perform as rated without heating system modifications, and concerns about reduced product durability. (DOE also considered all other concerns expressed by manufacturers in this analysis.) Below, DOE summarizes these issues, which were raised in manufacturer interviews, in order to obtain public comment and related data.

Diminished Ability To Serve the Replacement Market

In interviews, several manufacturers pointed out that over 90 percent of residential boiler sales are transacted in the replacement channel, rather than the new construction channel. They stated that the current residential boiler market is structured around the legacy venting infrastructures that exist in the vast majority of homes and that any regulation that eliminated 82 to 83-percent efficient products would be very disruptive to the market. Manufacturers argued that under this scenario, consumers would face much higher installation costs, as well as complex challenges in changing the layout of the boiler room and upgrading their venting and heat distribution systems. Manufacturers argued that these considerations may induce consumers to explore other HVAC options and may cause them to leave the boiler market entirely. Manufacturers also asserted that the elimination of 82 to 83-percent efficient products could be disruptive to the market because several manufacturers would have to eliminate commodity products that generate a majority of their sales and be forced to sell products for which they are less vertically integrated, which may cause them to exit the market entirely. Some manufacturers speculated that if this scenario were to play out, it could result in the loss of a substantial number of American manufacturing jobs.

Accordingly, DOE has considered this feedback when developing its analysis of installation costs (see section IV.F.2), shipments analysis (see section IV.G), and employment impacts analysis (see section IV.N).

Condensing Boilers May Not Perform As Rated Without System Improvements

Several manufacturers argued that condensing boilers may have overstated efficiencies in terms of actual results in the field if they are installed as replacements in legacy distribution systems that were designed to maintain hot water supply temperatures of 180–200 °F. Manufacturers stated that in these systems, return water temperatures will often be too high for condensing boilers to operate in condensing mode, thereby causing the boiler to be less efficient than its express rating. Manufacturers also stated that because condensing boilers are designed for lower maximum supply water temperatures, the heat distribution output of the heating system as a whole is often reduced, and the boiler may not be able to meet heat distribution requirements. This may require the implementation of additional heat distribution equipment within a particular system. Some manufacturers pointed out that reducing the supply water temperature also reduces the radiation component of some heat distribution units, which is essential for comfort and allows consumers to maintain a lower thermostat setting. Reducing the radiation component may require a higher thermostat setting to maintain comfort, thereby reducing overall system efficiency.

DOE recognizes this issue and considered it in the energy use analysis for residential boilers. See chapter 7 of the final rule TSD for additional details.

Reduced Product Durability and Reliability

Several manufacturers commented that higher-efficiency condensing boilers on the market have not demonstrated the same level of durability and reliability as lower-efficiency products. Manufacturers stated that condensing products require more upkeep and maintenance and generally do not last as long as non-condensing products. Several manufacturers pointed out that they generally incur large after-sale costs with their condensing products because of additional warranty claims. Maintenance calls for these boilers require more skilled technicians and occur more frequently than they do with non-condensing boilers.

DOE considered these comments when developing its estimates of repair and maintenance costs for residential boilers (see section IV.F.2.c) and product lifetime (IV.F.2.d).

4. Discussion of MIA Comments

During the NOPR public comment period, interested parties commented on assumptions and results described in the NOPR document and accompanying TSD, addressing several topics related to manufacturer impacts. These include: small business impacts and industry direct employment.

Small Business Impacts

Energy Kinetics commented that the introduction of new products in response to the proposed standard will put significant burden on small manufacturers due to the product development costs, carrying costs, distribution costs, and warehousing costs that will be incurred. Further, Energy Kinetics argued that the standard may result in consumers switching to high-mass cast iron products which would also put small manufacturers at a market disadvantage. (Energy Kinetics, No. 52 at p. 2) Consistent with the requirements of the Regulatory Flexibility Act (5 U.S.C. 601, *et seq.*), as amended, the Department analyzes the expected impacts of an energy conservation standard on small business residential boiler manufacturers directly regulated by DOE's standards. DOE understands that small manufacturers may be disproportionately affected by an energy conservation standard, and these impacts are discussed in section VI.B.

Direct Employment

Burnham commented that a standard requiring condensing units would have significant impacts on direct employment due to the elimination of cast iron products. (Burnham, No. 60 at pp. 1 & 4) In the manufacturer impact analysis, DOE analyzes the impacts on regulated residential boiler manufacturers. In this analysis, DOE estimates the decrease in direct employment due to an energy conservation standard in section V.B.2.b. Burnham also raised concerns about the impact of a standard requiring condensing efficiency levels on their cast iron foundries. (Burnham, No. 60 at p. 38) However, this rule does not adopt a condensing level for any equipment classes. A full explanation of the efficiency requirements by product class is provided in section V.B.2.a.

K. Emissions Analysis

The emissions analysis consists of two components. The first component estimates the effect of potential energy conservation standards on power sector and site (where applicable) combustion emissions of CO_2, NO_X, SO_2, and Hg. The second component estimates the impacts of potential standards on emissions of two additional greenhouse gases, CH_4 and N_2O, as well as the reductions to emissions of 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.

For the final rule, the analysis of power sector emissions used marginal emissions factors that were derived from data in *AEO 2015,* as described in section IV.M. The methodology used in the final rule is described in chapters 13 and 15 of the final rule TSD.

Combustion emissions of CH_4 and N_2O are estimated using emissions intensity factors published by the EPA, Greenhouse Gas (GHG) Emissions Factors Hub.[98] The FFC upstream emissions are estimated based on the methodology described in chapter 15 of the final rule 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 each ton of gas by the gas' global warming potential (GWP) over a 100-year time horizon. Based on the Fifth Assessment Report of the Intergovernmental Panel on Climate Change,[99] DOE used GWP values of 28 for CH_4 and 265 for N_2O.

Because the on-site operation of residential boilers 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.[100]

The amended standards will reduce use of fuel at the site and slightly reduce electricity use, thereby reducing power sector emissions. However, the highest efficiency levels (*i.e.,* the max-tech levels) considered for residential boilers would increase the use of electricity by the boiler. For the considered TSLs, DOE estimated the change in power sector and upstream emissions of CO_2, NO_X, SO_2, and Hg.[101]

The *AEO* incorporates the projected impacts of existing air quality regulations on emissions. *AEO 2015*

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

[99] 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.

[100] 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*).

[101] Note that in these cases, the reduction in site emissions of CO_2, NO_X, and SO_2 is larger than the increase in power sector emissions.

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. The estimated CO_2 emissions reductions do not account for the effects of the Clean Power Plan (CPP) final rule, which was announced by EPA on August 3, 2015. 80 FR 64662 (Oct. 23, 2015). The CPP establishes guidelines for States to follow in developing plans to reduce CO_2 emissions from existing fossil fuel-fired electric generating units. Under the CPP, marginal emissions factors for CO_2 from the power sector would be significantly lower than the values that DOE derived from AEO 2015. The CPP would have a negligible effect on the CO_2 emissions reduction estimated to result from the adopted AFUE and standby/off mode standards for residential boilers, however, as the power sector accounts for only 2.7 percent of the total CO_2 emissions reduction. The bulk of the emissions reduction comes from site emissions. See section V.B.6 for further discussion.

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.[102] 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,[103] 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.[104] On October 23, 2014, the DC Circuit lifted the stay of CSAPR.[105] Pursuant to this action, CSAPR went into effect (and CAIR ceased to be in effect) as of January 1, 2015.

EIA was not able to incorporate CSAPR into *AEO 2015,* so it assumes implementation of CAIR. Although DOE's analysis used emissions factors that assume that CAIR, not CSAPR, is the regulation in force, 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 in 2016, however, SO_2 emissions will fall as a result of the Mercury and Air Toxics Standards (MATS) for power plants. 77 FR 9304 (Feb. 16, 2012). In the 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 established by CAIR, so it is unlikely that excess SO_2 emissions allowances resulting from the lower electricity demand would be needed or used to permit offsetting increases in SO_2 emissions by any regulated EGU. Therefore, DOE believes that energy conservation standards will generally reduce SO_2 emissions in 2016 and beyond.[106]

CAIR established a cap on NO_X emissions in 28 eastern States and the District of Columbia.[107] 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 final rule 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 the MATS.

AHRI criticized DOE's inclusion of CO_2 emissions impact over a time period greatly exceeding that used to measure the economic costs. (AHRI, No. 64 at pp. 6–7) In response, DOE considers the impacts over the lifetime of the residential boiler products shipped in the 30-year analysis period. With respect to energy cost savings, impacts continue until all of the equipment shipped in the 30-year analysis period are retired. Likewise, emissions impacts from purchased

[102] 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).

[103] 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).

[104] *See 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.

[105] See *Georgia* v. *EPA,* Order (D.C. Cir. filed October 23, 2014) (No. 11–1302).

[106] DOE notes that the Supreme Court recently determined that EPA erred by not considering costs in the finding that regulation of hazardous air pollutants from coal-fired and oil-fired electric utility steam generating units is appropriate. See *Michigan* v. *EPA* (Case No. 14–46, 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 efficiency standards on SO_2 emissions (see chapter 13 of the final rule TSD for further discussion). Further, the Court's decision does not change the impact of the energy efficiency standards on mercury emissions. DOE will continue to monitor developments related to this case and respond to them as appropriate.

[107] CSAPR also applies to NO_X, and it supersedes 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.

products continue until all of the emissions produced by the boilers shipped during the analysis period are eliminated from the atmosphere. CO_2 that is emitted during the lifetime of the products has a long residence time in the atmosphere, and, thus, contributes to radiative forcing, which affects global climate, for a long time. In the case of both manufacturer economic costs and benefits and the value of CO_2 emissions reductions, DOE is accounting for the lifetime impacts of products shipped in the same analysis period.

EEI stated that the analysis and *AEO 2015* do not include the impact of the EPA power plant rule on coal power generation. (EEI, Public Meeting Transcript, No. 50 at pp. 270–272) *AEO 2015* is the only source that provides a comprehensive projection of Reference case emissions. The final rule for the Clean Power Plan was issued well after *AEO 2015* was finalized. DOE acknowledges that presuming the Clean Power Plan survives court challenges, projected emissions of CO_2 would be below those projected in *AEO 2015*. However, DOE notes that the adopted standards for residential boilers would be economically justified even if DOE did not account for any emissions benefits.

L. Monetizing Carbon Dioxide and Other Emissions Impacts

As part of the development of this rule, 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 analogous to the calculation of the NPV of consumer benefit, DOE considered the reduced emissions expected to result over the lifetime of products shipped in the 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 final rule.

For this final rule, DOE relied on a set of values for the social cost of carbon (SCC) that was developed by a Federal interagency process. The basis for these values is summarized in the next section, and a more detailed description of the methodologies used is provided as an appendix to chapter 14 of the final rule TSD.

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) climate-change-related 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 CO_2. A domestic SCC value is meant to reflect the value of damages in the United States resulting from a unit change in CO_2 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 these 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 CO_2 emissions, the analyst faces a number of challenges. A report from the National Research Council [108] points out that any assessment will suffer from uncertainty, speculation, and lack of information about: (1) Future emissions of GHGs; (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.

Despite the limits of both quantification and monetization, SCC estimates can be useful in estimating the social benefits of reducing CO_2 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 values appropriate for that year. The NPV of the benefits can then be calculated by multiplying each of these 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 Federal 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.

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

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. Specially, 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 the 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, was 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,[109] although preference is given to consideration of the global benefits of reducing CO_2 emissions. Table IV.28 presents the values in the 2010 interagency group report,[110] which is reproduced in appendix 14A of the final rule TSD.

TABLE IV.28—ANNUAL SCC VALUES FROM 2010 INTERAGENCY REPORT, 2010–2050

[In 2007$ 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).[111] Table IV.29 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 estimates between 2010 and 2050 is reported in appendix 14B of the final rule 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.29—ANNUAL SCC VALUES FROM 2013 INTERAGENCY UPDATE (REVISED JULY 2015), 2010–2050

[In 2007$ per metric ton CO_2]

Year	Discount rate			
	5%	3%	2.5%	3%
	Average	Average	Average	95th-percentile
2010	10	31	50	86
2015	11	36	56	105
2020	12	42	62	123

[109] 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.

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

[111] *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.29—ANNUAL SCC VALUES FROM 2013 INTERAGENCY UPDATE (REVISED JULY 2015), 2010–2050—Continued

[In 2007$ per metric ton CO_2]

Year	Discount rate			
	5%	3%	2.5%	3%
	Average	Average	Average	95th-percentile
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

Commenting on the NOPR, The Associations objected to DOE's continued use of the Social Cost of Carbon (''SCC'') and stated that the SCC calculation should not be used in any rulemaking or policymaking until it undergoes a more rigorous notice, review, and comment process. (The Associations, No. 56 at p. 4) Both The Associations[112] and AHRI stated that the interagency process was not transparent, that the SCC estimates were not subjected to peer review, and that the information generated violates the Information Quality Act (IAQ[113]). (AHRI, No. 64 at p. 8) In addition, AHRI stated that the SCC estimates relied on arbitrary damage functions. (AHRI, No. 64 at p. 8)

In response, DOE notes that the General Accounting Office (GAO) reviewed the Interagency Working Group's (IWG) development of SCC estimates and found that OMB and EPA participants reported that the IWG documented all major issues consistent with Federal standards for internal control. The GAO also found, according to its document review and interviews, that the IWG's development process followed three principles: (1) it used consensus-based decision making; (2) it relied on existing academic literature and models; and (3) it took steps to disclose limitations and incorporate new information.[114] DOE has also determined that this energy conservation standards rulemaking process has complied with the requirements of the Information Quality Act (see section VI.J).

AHRI and the Cato Institute criticized DOE's use of SCC estimates that DOE has acknowledged are subject to considerable uncertainty. (AHRI, No. 64 at pp. 5–6; Cato Institute, No. 51 at p. 3) The Cato Institute stated that until the integrated assessment models (IAMs) are made consistent with mainstream climate science, the SCC should be barred from use in this and all other Federal rulemakings. The Cato Institute criticized several aspects of the determination of the SCC values by the IWG as being discordant with the best climate science and not reflective of climate change impacts. (Cato Institute, No. 51 at p. 1–2, 4–22) AHRI also criticized the determination of the SCC values. (AHRI, No. 64 at p. 8)

In conducting the interagency process that developed the SCC values, 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. Key uncertainties and model differences transparently and consistently inform the range of SCC estimates. These uncertainties and model differences are discussed in the interagency working group's reports, which are reproduced in appendices 14A and 14B of the final rule TSD, as are the major assumptions. Specifically, uncertainties in the assumptions regarding climate sensitivity, as well as other model inputs such as economic growth and emissions trajectories, are discussed and the reasons for the specific input assumptions chosen are explained. However, the three integrated assessment models used to estimate the SCC are frequently cited in the peer-reviewed literature and were used in the last assessment of the IPCC. In addition, new versions of the models that were used in 2013 to estimate revised SCC values were published in the peer-reviewed literature (see appendix 14B of the final rule TSD for discussion). Although uncertainties remain, the revised estimates that were issued in November 2013 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, using the best science available, and with input from the public. In November 2013, OMB announced a new opportunity for public comment 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.[115] OMB 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.

AHRI, the Cato Institute, and Laclede criticized DOE's use of global rather than domestic SCC values, pointing out that EPCA references weighing of the need for national energy conservation. The Cato Institute recommended reporting the results of the domestic SCC calculation in the main body of the proposed regulation. (AHRI, No. 64 at p. 6; Cato Institute, No. 51 at pp. 2–3; Laclede, No. 58 at p. 9)

In response, DOE's analysis estimates both global and domestic benefits of CO_2 emissions reductions. The domestic benefits are reported in chapter 14 of the

[112] Comments submitted to the Commercial Refrigeration Equipment which the Associations incorporated by reference (Comments of the U.S. Chamber of Commerce, American Forest & Paper Association, American Fuel & Petrochemical Manufacturers, American Petroleum Institute, Council of Industrial Boiler Owners, National Association of Manufacturers, National Mining Association, and Portland Cement Association; Docket No. EERE–2010–BT–STD–0003–0079; *http://www.regulations.gov/#!documentDetail;D=EERE-2010-BT-STD-0003-0079*).

[113] Public Law 106–554, § 515, 114 Stat. 2763 (Dec. 21, 2000). The IAQ is also set forth at 44 U.S.C. 3516, note.

[114] U.S. Government Accountability Office, *Regulatory Impact Analysis: Development of Social Cost of Carbon Estimates GAO–14–663* (July 24, 2014) (Available at: *http://www.gao.gov/products/GAO–14–663*).

[115] The White House, *Estimating the Benefits from Carbon Dioxide Emissions Reductions* (July 2, 2015) (Available at: *https://www.whitehouse.gov/blog/2015/07/02/estimating-benefits-carbon-dioxide-emissions-reductions*).

final rule TSD. Following the recommendation of the Interagency Working Group, DOE places more focus on a global measure of SCC. As discussed in appendix 14A of the final rule TSD, the climate change problem is highly unusual in at least two respects. First, it involves a global externality: Emissions of most greenhouse gases contribute to damages around the world even when they are emitted in the United States. Consequently, to address the global nature of the problem, the SCC must incorporate the full (global) damages caused by GHG emissions. Second, climate change presents a problem that the United States alone cannot solve. Even if the United States were to reduce its greenhouse gas emissions to zero, that step would be far from enough to avoid substantial climate change. Other countries would also need to take action to reduce emissions if significant changes in the global climate are to be avoided. Emphasizing the need for a global solution to a global problem, the United States has been actively involved in seeking international agreements to reduce emissions and in encouraging other nations, including emerging major economies, to take significant steps to reduce emissions. When these considerations are taken as a whole, the interagency group concluded that a global measure of the benefits from reducing U.S. emissions is preferable. Therefore, DOE's approach is not in contradiction of the requirement to weigh the need for national energy conservation, as one of the main reasons for national energy conservation is to contribute to efforts to mitigate the effects of global climate change.

AHRI disputed DOE's assumption that SCC values will increase over time, because AHRI reasons that the more economic development that occurs, the more adaptation and mitigation efforts that will be undertaken. (AHRI, No. 64 at p. 7) In response, the SCC increases over time because future emissions are expected to produce larger incremental damages as physical and economic systems become more stressed in response to greater climatic change (see appendix 14A of the final rule TSD). The approach used by the Interagency Working Group allowed estimation of the growth rate of the SCC directly using the three IAMs, which helps to ensure that the estimates are internally consistent with other modeling assumptions. Adaptation and mitigation efforts, while necessary and important, are not without cost, particularly if their implementation is delayed.

Laclede recommended using market prices to value carbon reduction benefits to U.S. residents. Laclede provided a chart of DOE's SCC values compared to three market prices from 2008 to 2015, which shows that the market prices are as low as or lower than the SCC value at a 5-percent discount rate ($12). (Laclede, No. 58 at pp. 9–10) In response, DOE notes that market prices are simply a reflection of the conditions in specific emissions markets in which emissions caps have been set. Neither the caps nor the resulting prices of traded emissions are intended to reflect the full range of domestic and global impacts from anthropogenic climate change over the appropriate time scales.

Even though the SCC embodies the best data currently available, it is important to recognize that a number of key uncertainties remain, and that current SCC estimates should be treated as provisional and revisable because 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 previously 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.

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 implicit price deflator for gross domestic product (GDP) from the Bureau of Economic Analysis. For each of the four sets of SCC cases specified, the values 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 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, which are presented in chapter 14 of the direct final rule 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 to evaluate the monetization of avoided NO_X emissions and will make any appropriate updates in energy conservation standards rulemakings.

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 the NEMS associated with *AEO 2015.* NEMS produces the *AEO* Reference case, as well as a number of side cases that estimate the economy-wide impacts of changes to energy supply and demand. DOE uses published side cases 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 final rule TSD.

The output of this analysis is a set of time-dependent coefficients that capture the change in electricity generation, primary fuel consumption, installed capacity and power sector emissions due to a unit reduction in demand for a given end use. These coefficients are multiplied by the stream of electricity savings calculated in the NIA to provide estimates of selected utility impacts of new or amended energy conservation standards.

N. Employment Impact Analysis

DOE considers employment impacts in the domestic economy as one factor in selecting a standard. Employment impacts from new or amended energy conservation standards include both direct and indirect impacts. Direct employment impacts are any changes in the number of employees of manufacturers of the products subject to standards. The MIA addresses those impacts. Indirect employment impacts are changes in national employment that occur due to the shift in expenditures and capital investment caused by the purchase and operation of more-efficient appliances. Indirect employment impacts from standards consist of the net jobs created or eliminated in the national economy, other than in the manufacturing sector being regulated, caused by: (1) Reduced spending by end users on energy; (2) reduced spending on new energy supply by the utility industry; (3) increased consumer spending on new products to which the new standards apply; 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).[116] 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.[117] There are many reasons for these differences, including wage differences and the fact that the utility sector is more capital-intensive and less labor-intensive than other sectors. Energy conservation standards have the effect of reducing consumer utility bills. Because reduced consumer expenditures for energy likely lead to increased expenditures in other sectors of the economy, the general effect of efficiency standards is to shift economic activity from a less labor-intensive sector (*i.e.,* the utility sector) to more labor-intensive sectors (*e.g.,* the retail and service sectors). Thus, based on the BLS data alone, DOE believes net national employment may increase due to shifts in economic activity resulting from amended energy conservation standards for residential boilers.

DOE estimated indirect national employment impacts for the standard levels considered in this final rule using an input/output model of the U.S. economy called Impact of Sector Energy Technologies version 3.1.1 (ImSET).[118] ImSET is a special-purpose version of the ''U.S. Benchmark National Input-Output'' (I–O) model, which was designed to estimate the national employment and income effects of energy-saving technologies. The ImSET software includes a computer-based I–O model having structural coefficients that characterize economic flows among 187 sectors most relevant to industrial, commercial, and residential building energy use.

DOE notes that ImSET is not a general equilibrium forecasting model, and understands the uncertainties involved in projecting employment impacts, especially changes in the later years of the analysis. Because ImSET does not incorporate price changes, the employment effects predicted by ImSET may over-estimate actual job impacts over the long run for this rule. Therefore, DOE generated results for near-term timeframes (through 2023), where these uncertainties are reduced. For more details on the employment impact analysis, see chapter 16 of the final rule TSD.

V. Analytical Results and Conclusions

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

A. Trial Standard Levels

DOE analyzed the benefits and burdens of five TSLs for residential boilers for AFUE standards and three TSLs for standby mode and off mode standards. These TSLs were developed by combining specific efficiency levels for each of the product classes analyzed by DOE. DOE presents the results for the TSLs in this document, while the results for all efficiency levels that DOE analyzed are in the final rule TSD.

1. TSLs for AFUE Standards

Table V.1 and Table V.2 present the TSLs and the corresponding product classes that DOE considered for residential boilers by efficiency levels and AFUE levels, respectively TSL 5 consists of the max-tech efficiency levels. TSL 4 consists of intermediate efficiency levels between the max-tech and TSL3, including the minimum condensing efficiency levels for hot water boiler product classes. TSL 3 consists of the efficiency levels that provide the highest NPV using a 7-percent discount rate (see section V.B.3 for NPV results)., and that also result in a higher percentage of consumers that receive an LCC benefit than experience an LCC loss (see section V.B.1 for LCC results). TSL 2 consists of the intermediate efficiency levels. TSL 1 consists of the most common efficiency levels in the current market.

[116] Data on industry employment, hours, labor compensation, value of production, and the implicit price deflator for output for these industries are available upon request by calling the Division of Industry Productivity Studies (202–691–5618) or by sending a request by email to *dipsweb@bls.gov.*

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

[118] J. M. Roop, M. J. Scott, and R. W. Schultz, *ImSET 3.1: Impact of Sector Energy Technologies,* PNNL–18412, Pacific Northwest National Laboratory. 2009. (Available at: *http://www.pnl.gov/main/publications/exbleternal/technical_reports/PNNL-18412.pdf*)

TABLE V.1—TRIAL STANDARD LEVELS FOR RESIDENTIAL BOILERS BY EFFICIENCY LEVEL

Product class*	Trial Standard Levels				
	1	2	3	4	5
Gas-Fired Hot Water Boiler	1	1	2	4	6
Gas-Fired Steam Boiler	1	1	1	1	2
Oil-Fired Hot Water Boiler	1	2	2	3	3
Oil-Fired Steam Boiler	1	1	2	3	3

*As discussed in section IV.A.1, although electric hot water and electric steam boilers are in the scope of this rulemaking, these products were not analyzed for AFUE energy conservation standards and accordingly are not shown in this table.

TABLE V.2—TRIAL STANDARD LEVELS FOR RESIDENTIAL BOILERS BY AFUE

Product class*	Trial Standard Levels				
	1 (%)	2 (%)	3 (%)	4 (%)	5 (%)
Gas-Fired Hot Water Boiler	83	83	84	90	96
Gas-Fired Steam Boiler	82	82	82	82	83
Oil-Fired Hot Water Boiler	85	86	86	91	91
Oil-Fired Steam Boiler	84	84	85	86	86

*As discussed in section IV.A.1, electric hot water and electric steam boilers were not analyzed for AFUE energy conservation standards and accordingly are not shown in this table.

2. TSLs for Standby Mode and Off Mode Standards

Table V.3 presents the TSLs and the corresponding product class efficiency levels (by efficiency level) that DOE considered for boiler standby mode and off mode power consumption. Table V.4 presents the three TSLs and the corresponding product class efficiency levels (expressed in watts) that DOE considered for boiler standby mode and off mode power consumption. TSL 3 consists of efficiency levels that utilize the technology option Switching Mode Power Supply with Low-Loss Transformer (LLTX). TSL 2 consists of efficiency levels that utilize the technology option Switching Mode Power Supply. TSL 1 consists of efficiency levels that utilize the technology option Linear Power Supply with LLTX.

TABLE V.3—STANDBY MODE AND OFF MODE TRIAL STANDARD LEVELS FOR RESIDENTIAL BOILERS BY EFFICIENCY LEVEL

Product class	Trial Standard Levels		
	1	2	3
Gas-Fired Hot Water Boiler	1	2	3
Gas-Fired Steam Boiler	1	2	3
Oil-Fired Hot Water Boiler	1	2	3
Oil-Fired Steam Boiler	1	2	3
Electric Hot Water Boiler	1	2	3
Electric Steam Boiler	1	2	3

TABLE V.4—STANDBY MODE AND OFF MODE TRIAL STANDARD LEVELS FOR RESIDENTIAL BOILERS BY WATTS

Product class	Trial Standard Levels		
	1	2	3
Gas-Fired Hot Water Boiler	10.0	9.7	9.0
Gas-Fired Steam Boiler	9.0	8.7	8.0
Oil-Fired Hot Water Boiler	12.0	11.7	11.0
Oil-Fired Steam Boiler	12.0	11.7	11.0
Electric Hot Water Boiler	9.0	8.7	8.0
Electric Steam Boiler	9.0	8.7	8.0

B. Economic Justification and Energy Savings

1. Economic Impacts on Individual Consumers

DOE analyzed the economic impacts on residential boilers consumers by looking at the effects potential amended standards at each TSL would have on the LCC and PBP. DOE also examined the impacts of potential standards on consumer subgroups. These analyses are discussed below.

a. Life-Cycle Cost and Payback Period

In general, higher-efficiency products affect consumers in two ways: (1) Purchase price increases and (2) annual operating costs decrease. Inputs used for calculating the LCC and PBP include total installed costs (*i.e.,* product price plus installation costs), and operating costs (*i.e.,* annual energy use, energy prices, energy price trends, repair costs, and maintenance costs). The LCC calculation also uses product lifetime and a discount rate. Chapter 8 of the final rule TSD provides detailed information on the LCC and PBP analyses.

Table V.5 through Table V.12 show the LCC and PBP results for the AFUE TSLs considered for each product class. In the first of each pair of tables, the simple payback is measured relative to the baseline product. In the second table, the impacts are measured relative to the efficiency distribution in the no-new-standards case in the compliance year (see section IV.F.8 of this notice). Because some consumers purchase products with higher efficiency in the no-new-standards case, the average savings are less than the difference between the average LCC of the baseline product and the average LCC at each TSL. The savings refer only to consumers who are affected by a standard at a given TSL. Those who already purchase a product with efficiency at or above a given TSL are not affected. Consumers for whom the LCC increases at a given TSL experience a net cost.

TABLE V.5—AVERAGE LCC AND PBP RESULTS FOR GAS-FIRED HOT WATER BOILERS: AFUE STANDARDS

TSL	AFUE (%)	Average costs (2014$)				Simple payback (years)	Average lifetime (years)
		Total installed cost	First year's operating cost	Lifetime operating cost	LCC		
1	83	$6,387	$1,211	$22,468	$28,854	1.2	26.6
2	83	6,387	1,211	22,468	28,854	1.2	26.6
3	84	6,402	1,198	22,235	28,638	1.2	26.6
4	90	7,255	1,119	20,761	28,016	8.4	26.6
5	96	8,295	1,061	19,700	27,995	11.8	26.6

Note: The results for each TSL are calculated assuming that all consumers use products at that efficiency level. The PBP is measured relative to the baseline (EL 0) product.

TABLE V.6—AVERAGE LCC SAVINGS RELATIVE TO THE NO-NEW-STANDARDS CASE FOR GAS-FIRED HOT WATER BOILERS: AFUE STANDARDS

TSL	AFUE (%)	Life-cycle cost savings	
		% of consumers that experience net cost	Average savings * (2014$)
1	83	0.3	$210
2	83	0.3	210
3	84	0.4	364
4	90	21.9	632
5	96	55.5	303

* The savings represent the average LCC for affected consumers.

TABLE V.7—AVERAGE LCC AND PBP RESULTS FOR GAS-FIRED STEAM BOILERS: AFUE STANDARDS

TSL	AFUE (%)	Average costs (2014$)				Simple payback (years)	Average lifetime (years)
		Total installed cost	First year's operating cost	Lifetime operating cost	LCC		
1	82	$6,376	$1,063	$17,857	$24,234	2.7	23.6
2	82	6,376	1,063	17,857	24,234	2.7	23.6
3	82	6,376	1,063	17,857	24,234	2.7	23.6
4	82	6,376	1,063	17,857	24,234	2.7	23.6
5	83	6,682	1,052	17,672	24,355	10.7	23.6

Note: The results for each TSL are calculated assuming that all consumers use products at that efficiency level. The PBP is measured relative to the baseline (EL 0) product.

TABLE V.8—AVERAGE LCC SAVINGS RELATIVE TO THE NO-NEW-STANDARDS CASE FOR GAS-FIRED STEAM BOILERS: AFUE STANDARDS

TSL	AFUE (%)	Life-cycle cost savings	
		% of consumers that experience net cost	Average savings * (2014$)
1	82	0.9	$333
2	82	0.9	333
3	82	0.9	333
4	82	0.9	333

TABLE V.8—AVERAGE LCC SAVINGS RELATIVE TO THE NO-NEW-STANDARDS CASE FOR GAS-FIRED STEAM BOILERS: AFUE STANDARDS—Continued

TSL	AFUE (%)	Life-cycle cost savings	
		% of consumers that experience net cost	Average savings * (2014$)
5	83	30.8	207

* The savings represent the average LCC for affected consumers.

TABLE V.9—AVERAGE LCC AND PBP RESULTS FOR OIL-FIRED HOT WATER BOILERS: AFUE STANDARDS

TSL	AFUE (%)	Average costs (2014$)				Simple payback (years)	Average lifetime (years)
		Total installed cost	First year's operating cost	Lifetime operating cost	LCC		
1	85	$8,200	$1,999	$38,553	$46,753	6.9	24.7
2	86	8,351	1,969	37,962	46,313	5.8	24.7
3	86	8,351	1,969	37,962	46,313	5.8	24.7
4	91	10,691	1,861	35,842	46,534	16.5	24.7
5	91	10,691	1,861	35,842	46,534	16.5	24.7

Note: The results for each TSL are calculated assuming that all consumers use products at that efficiency level. The PBP is measured relative to the baseline (EL 0) product.

TABLE V.10—AVERAGE LCC SAVINGS RELATIVE TO THE NO-NEW-STANDARDS CASE FOR OIL-FIRED HOT WATER BOILERS: AFUE STANDARDS

TSL	AFUE (%)	Life-cycle cost savings	
		% of consumers that experience net cost	Average savings * (2014$)
1	85	10.4	$260
2	86	8.8	626
3	86	8.8	626
4	91	58.9	192
5	91	58.9	192

* The savings represent the average LCC for affected consumers.

TABLE V.11—AVERAGE LCC AND PBP RESULTS FOR OIL-FIRED STEAM BOILERS: AFUE STANDARDS

TSL	AFUE (%)	Average costs (2014$)				Simple payback (years)	Average lifetime (years)
		Total installed cost	First year's operating cost	Lifetime operating cost	LCC		
1	84	$8,189	$1,928	$29,558	$37,747	6.6	19.3
2	84	8,189	1,928	29,558	37,747	6.6	19.3
3	85	8,341	1,906	29,219	37,560	6.7	19.3
4	86	8,644	1,876	28,760	37,404	7.8	19.3
5	86	8,644	1,876	28,760	37,404	7.8	19.3

Note: The results for each TSL are calculated assuming that all consumers use products at that efficiency level. The PBP is measured relative to the baseline (EL 0) product.

TABLE V.12—AVERAGE LCC SAVINGS RELATIVE TO THE NO-NEW-STANDARDS CASE FOR OIL-FIRED STEAM BOILERS: AFUE STANDARDS

TSL	AFUE (%)	Life-cycle cost savings	
		Percent of consumers that experience net cost	Average savings * (2014$)
1	84	11.9	$400
2	84	11.9	400
3	85	19.7	434
4	86	34.2	505

TABLE V.12—AVERAGE LCC SAVINGS RELATIVE TO THE NO-NEW-STANDARDS CASE FOR OIL-FIRED STEAM BOILERS: AFUE STANDARDS—Continued

TSL	AFUE (%)	Life-cycle cost savings	
		Percent of consumers that experience net cost	Average savings* (2014$)
5	86	34.2	505

* The savings represent the average LCC for affected consumers.

Table V.13 through Table V.24 show the key LCC and PBP results for each product class for standby mode and off mode.

TABLE V.13—AVERAGE LCC AND PBP RESULTS FOR GAS-FIRED HOT WATER BOILERS: STANDBY MODE AND OFF MODE STANDARDS

TSL	Average costs (2014$)				Simple payback (years)	Average lifetime (years)
	Installed cost	First year's operating cost	Lifetime operating cost	LCC		
1	$32	$12	$225	$257	2.0	26.6
2	49	12	218	267	8.9	26.6
3	50	11	202	251	6.7	26.6

Note: The results for each TSL are calculated assuming that all consumers use products at that efficiency level. The PBP is measured relative to the baseline (EL 0) product.

TABLE V.14—AVERAGE LCC SAVINGS RELATIVE TO THE NO-NEW-STANDARDS CASE FOR GAS-FIRED HOT WATER BOILERS: STANDBY MODE AND OFF MODE STANDARDS

TSL	Life-cycle cost savings	
	Percent of consumers that experience net cost	Average savings* (2014$)
1	0.0	$26
2	3.7	2
3	1.8	15

* The savings represent the average LCC for affected consumers.

TABLE V.15—AVERAGE LCC AND PBP RESULTS FOR GAS-FIRED STEAM BOILERS: STANDBY MODE AND OFF MODE STANDARDS

TSL	Average costs (2014$)				Simple payback (years)	Average lifetime (years)
	Installed cost	First year's operating cost	Lifetime operating cost	LCC		
1	$31	$12	$194	$226	1.9	23.6
2	48	11	188	236	8.5	23.6
3	49	10	172	221	6.4	23.6

Note: The results for each TSL are calculated assuming that all consumers use products at that efficiency level. The PBP is measured relative to the baseline (EL 0) product.

TABLE V.16—AVERAGE LCC SAVINGS RELATIVE TO THE NO-NEW-STANDARDS CASE FOR GAS-FIRED STEAM BOILERS: STANDBY MODE AND OFF MODE STANDARDS

TSL	Life-cycle cost savings	
	Percent of consumers that experience net cost	Average savings* (2014$)
1	0.0	$31
2	1.3	4

TABLE V.16—AVERAGE LCC SAVINGS RELATIVE TO THE NO-NEW-STANDARDS CASE FOR GAS-FIRED STEAM BOILERS: STANDBY MODE AND OFF MODE STANDARDS—Continued

TSL	Life-cycle cost savings	
	Percent of consumers that experience net cost	Average savings* (2014$)
3	0.5	18

*The savings represent the average LCC for affected consumers.

TABLE V.17—AVERAGE LCC AND PBP RESULTS FOR OIL-FIRED HOT WATER BOILERS: STANDBY MODE AND OFF MODE STANDARDS

TSL	Average costs (2014$)				Simple payback (years)	Average lifetime (years)
	Installed cost	First year's operating cost	Lifetime operating cost	LCC		
1	$31	$16	$281	$313	1.8	24.7
2	48	16	274	322	8.2	24.7
3	49	15	258	307	6.2	24.7

Note: The results for each TSL are calculated assuming that all consumers use products at that efficiency level. The PBP is measured relative to the baseline (EL 0) product.

TABLE V.18—AVERAGE LCC SAVINGS RELATIVE TO THE NO-NEW-STANDARDS CASE FOR OIL-FIRED HOT WATER BOILERS: STANDBY MODE AND OFF MODE STANDARDS

TSL	Life-cycle cost savings	
	Percent of consumers that experience net cost	Average savings* (2014$)
1	0.0	$32
2	3.5	6
3	1.4	20

*The savings represent the average LCC for affected consumers.

TABLE V.19—AVERAGE LCC AND PBP RESULTS FOR OIL-FIRED STEAM BOILERS: STANDBY MODE AND OFF MODE STANDARDS

TSL	Average costs (2014)				Simple payback (years)	Average lifetime (years)
	Installed cost	First year's operating cost	Lifetime operating cost	LCC		
1	$31	$17	$236	$268	1.8	19.3
2	48	16	230	278	8.0	19.3
3	49	15	216	265	6.1	19.3

Note: The results for each TSL are calculated assuming that all consumers use products at that efficiency level. The PBP is measured relative to the baseline (EL 0) product.

TABLE V.20—AVERAGE LCC SAVINGS RELATIVE TO THE NO-NEW-STANDARDS CASE FOR OIL-FIRED STEAM BOILERS: AFUE STANDARDS

TSL	Life-cycle cost savings	
	Percent of consumers that experience net cost	Average savings* (2014$)
1	0.0	$26
2	1.3	0.4
3	0.6	13

*The savings represent the average LCC for affected consumers.

TABLE V.21—AVERAGE LCC AND PBP RESULTS FOR ELECTRIC HOT WATER BOILERS: STANDBY MODE AND OFF MODE STANDARDS

TSL	Average costs (2014$)				Simple payback (years)	Average lifetime (years)
	Installed cost	First year's operating cost	Lifetime operating cost	LCC		
1	$31	$8	$145	$176	2.6	26.6
2	47	8	141	188	11.7	26.6
3	48	7	129	177	8.9	26.6

Note: The results for each TSL are calculated assuming that all consumers use products at that efficiency level. The PBP is measured relative to the baseline (EL 0) product.

TABLE V.22—AVERAGE LCC SAVINGS RELATIVE TO THE NO-NEW-STANDARDS CASE FOR ELECTRIC HOT WATER BOILERS: STANDBY MODE AND OFF MODE STANDARDS

TSL	Life-cycle cost savings	
	Percent of consumers that experience net cost	Average savings* (2014$)
1	0.0	$19
2	1.5	(3)
3	1.0	8

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

TABLE V.23—AVERAGE LCC AND PBP RESULTS FOR ELECTRIC STEAM BOILERS: STANDBY MODE AND OFF MODE STANDARDS

TSL	Average costs (2014$)				Simple payback (years)	Average lifetime (years)
	Installed cost	First year's operating cost	Lifetime operating cost	LCC		
1	$31	$9	$133	$164	2.6	23.6
2	47	8	129	176	11.7	23.6
3	48	8	118	166	8.8	23.6

Note: The results for each TSL are calculated assuming that all consumers use products at that efficiency level. The PBP is measured relative to the baseline (EL 0) product.

TABLE V.24—AVERAGE LCC SAVINGS RELATIVE TO THE NO-NEW-STANDARDS CASE FOR ELECTRIC STEAM BOILERS: STANDBY MODE AND OFF MODE STANDARDS

TSL	Life-cycle cost savings	
	Percent of consumers that experience net cost	Average savings* (2014$)
1	0	$17
2	1.5	(5)
3	1.0	6

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

b. Consumer Subgroup Analysis

In the consumer subgroup analysis, DOE estimated the impact of the considered AFUE TSLs on low-income households and senior-only households. Table V.25 through Table V.28 compare the average LCC savings and simple PBPs at each efficiency level for the two consumer subgroups, along with the average LCC savings for the entire sample. Chapter 11 of the final rule TSD presents the complete LCC and PBP results for the subgroups, as well as the standby mode and off mode standards results.

TABLE V.25.—COMPARISON OF IMPACTS FOR CONSUMER SUBGROUPS WITH ALL CONSUMERS, GAS-FIRED HOT WATER BOILERS: AFUE STANDARDS

TSL	Average life-cycle cost savings (2014$)	Simple payback period (years)				
		Senior-only	Low-income	All households	Senior-only	Low-income
1	$172	$161	$210	1.3	1.5	1.2
2	172	161	210	1.3	1.5	1.2
3	292	275	364	1.3	1.5	1.2
4	345	(89)	632	8.6	15.6	8.4
5	67	(200)	303	12.4	18.2	11.8

Note: Parentheses indicate negative values.

TABLE V.26—COMPARISON OF IMPACTS FOR CONSUMER SUBGROUPS WITH ALL CONSUMERS, GAS-FIRED STEAM BOILERS: AFUE STANDARDS

TSL	Average life-cycle cost savings (2014$)			Simple payback period (years)		
	Senior-only	Low-income	All households	Senior-only	Low-income	All households
1	$306	$265	$333	3.2	2.9	2.7
2	306	265	333	3.2	2.9	2.7
3	306	265	333	3.2	2.9	2.7
4	306	265	333	3.2	2.9	2.7
5	124	116	207	12.0	12.7	10.7

TABLE V.27—COMPARISON OF IMPACTS FOR CONSUMER SUBGROUPS WITH ALL CONSUMERS, OIL-FIRED HOT WATER BOILERS: AFUE STANDARDS

TSL	Average life-cycle cost savings (2014$)			Simple payback period (years)		
	Senior-only	Low-income	All households	Senior-only	Low-income	All households
1	$282	$82	$260	6.5	10.6	6.9
2	690	292	626	5.4	8.6	5.8
3	690	292	626	5.4	8.6	5.8
4	144	(1,260)	192	16.4	30.6	16.5
5	144	(1,260)	192	16.4	30.6	16.5

Note: Parentheses indicate negative values.

TABLE V.28—COMPARISON OF IMPACTS FOR CONSUMER SUBGROUPS WITH ALL CONSUMERS, OIL-FIRED STEAM BOILERS: AFUE STANDARDS

TSL	Average life-cycle cost savings (2014$)			Simple payback period (years)		
	Senior-only	Low-income	All households	Senior-only	Low-income	All households
1	$425	$138	$400	6.3	10.4	6.6
2	425	138	400	6.3	10.4	6.6
3	465	141	434	6.4	10.5	6.7
4	543	96	505	7.4	12.2	7.8
5	543	96	505	7.4	12.2	7.8

c. Rebuttable Presumption Payback Period

As discussed in section III.E.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. In calculating a rebuttable presumption payback period for each of the considered TSLs, DOE used discrete values, and, as required by EPCA, based the energy use calculation on the DOE test procedures for residential boilers. In contrast, the PBPs presented in section V.B.1.a were calculated using distributions that reflect the range of energy use in the field.

Table V.29 presents the rebuttable-presumption PBPs for the considered AFUE TSLs for the residential boilers product classes. Table V.30 shows the rebuttable-presumption PBPs for the considered standby mode and off mode TSLs for the residential boilers product classes. While DOE examined the rebuttable-presumption criterion, it considered whether the standard levels considered for this rule are economically justified through a more detailed analysis of the economic impacts of those levels, pursuant to 42 U.S.C. 6295(o)(2)(B)(i), that considers the full range of impacts to the consumer, manufacturer, Nation, and environment. The results of that analysis serve as the basis for DOE to definitively evaluate the economic justification for a potential standard level, thereby supporting or rebutting the results of any preliminary determination of economic justification.

TABLE V.29—REBUTTABLE-PRESUMPTION PAYBACK PERIODS FOR RESIDENTIAL BOILERS: AFUE STANDARDS

TSL	Gas-fired hot water boiler	Gas-fired steam boiler	Oil-fired hot water boiler	Oil-fired steam boiler
1	1.6	2.7	7.9	6.0
2	1.6	2.7	7.0	6.0
3	1.7	2.7	7.0	6.7
4	11.3	2.7	16.7	8.3
5	15.5	11.5	16.7	8.3

TABLE V.30—STANDBY MODE AND OFF MODE REBUTTABLE-PRESUMPTION PAYBACK PERIODS FOR RESIDENTIAL BOILERS: STANDBY MODE AND OFF MODE STANDARDS

TSL	Gas-fired hot water boiler	Gas-fired steam boiler	Oil-fired hot water boiler	Oil-fired steam boiler	Electric hot water boiler	Electric steam boiler
1	3.5	3.5	3.4	3.5	3.0	2.7
2	15.7	15.7	15.4	15.5	13.6	13.5
3	11.9	11.9	11.7	11.7	10.3	10.2

2. Economic Impacts on Manufacturers

DOE performed an MIA to estimate the impact of amended energy conservation standards on manufacturers of residential boilers. The section below describes the expected impacts on manufacturers at each considered TSL. DOE first discusses the impacts of potential AFUE standards and then turns to the impacts of potential standby mode and off mode standards. Chapter 12 of the final rule TSD explains the analysis in further detail.

a. Industry Cash-Flow Analysis Results

Cash-Flow Analysis Results for Residential Boilers AFUE Standards

Table V.31 and Table V.32 depict the estimated financial impacts (represented by changes in INPV) of amended energy conservation standards on manufacturers of residential boilers, as well as the conversion costs that DOE expects manufacturers would incur for all product classes at each TSL. To evaluate the range of cash-flow impacts on the residential boiler industry, DOE modeled two different 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 scenario; and (2) the preservation of per-unit operating profit scenario. Each of these scenarios is discussed immediately below.

To assess the lower (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 higher (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 products 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 IV.J.2), in addition to markup scenarios, the MPC, shipments, and conversion cost assumptions also affect INPV results.

The results in Table V.31 and Table V.32 show potential INPV impacts for residential boiler manufacturers; Table V.31 reflects the lower bound of impacts, and Table V.32 represents the upper bound of impacts.

Each of the modeled scenarios in the AFUE standards analysis results in a unique set of cash flows and corresponding industry values at each TSL. In the following discussion, the INPV results refer to the difference in industry value between the no-new-standards case and each standards case that results from the sum of discounted cash flows from the base year 2014 through 2050, 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 would 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.31—MANUFACTURER IMPACT ANALYSIS FOR RESIDENTIAL BOILERS FOR AFUE STANDARDS—PRESERVATION OF GROSS MARGIN PERCENTAGE MARKUP SCENARIO *

	Units	No-new-standards case	Trial Standard Level				
			1	2	3	4	5
INPV	2014$ millions	367.83	367.50	368.69	369.45	349.47	366.71

TABLE V.31—MANUFACTURER IMPACT ANALYSIS FOR RESIDENTIAL BOILERS FOR AFUE STANDARDS—PRESERVATION OF GROSS MARGIN PERCENTAGE MARKUP SCENARIO *—Continued

	Units	No-new-standards case	Trial Standard Level				
			1	2	3	4	5
Change in INPV	2014$ millions		(0.33)	0.86	1.62	(18.35)	(1.12)
	%		(0.09)	0.24	0.44	(4.99)	(0.30)
Product Conversion Costs	2014$ millions		1.34	1.60	1.66	24.53	37.19
Capital Conversion Costs	2014$ millions			0.43	0.61	61.10	69.52
Total Conversion Costs	2014$ millions		1.34	2.03	2.27	85.63	106.71
Free Cash Flow (no-new-standards case = 2019)	2014$ millions	26.42	26.01	25.74	25.64	(8.43)	(16.02)
Change in Free Cash Flow (change from no-new-standards case)	2014$ millions		(0.4)	(0.7)	(0.8)	(34.9)	(42.4)
	%		(1.52)	(2.55)	(2.92)	(131.93)	(160.65)

* Parentheses indicate negative values.

TABLE V.32—MANUFACTURER IMPACT ANALYSIS FOR RESIDENTIAL BOILERS FOR AFUE STANDARDS—PRESERVATION OF PER-UNIT OPERATING PROFIT MARKUP SCENARIO *

	Units	No-new-standards case	Trial Standard Level				
			1	2	3	4	5
INPV	2014$ millions	367.83	365.70	364.94	365.20	284.21	225.88
Change in INPV	2014$ millions		(2.12)	(2.89)	(2.63)	(83.61)	(141.95)
	%		(0.58)	(0.79)	(0.71)	(22.73)	(38.59)
Product Conversion Costs	2014$ millions		1.34	1.60	1.66	24.53	37.19
Capital Conversion Costs	2014$ millions			0.43	0.61	61.10	69.52
Total Conversion Costs	2014$ millions		1.34	2.03	2.27	85.63	106.71
Free Cash Flow (no-new-standards case = 2019)	2014$ millions	26.42	26.01	25.74	25.64	(8.43)	(16.02)
Change in Free Cash Flow (change from the no-new-standards case)	2014$ millions		(0.4)	(0.7)	(0.8)	(34.9)	(42.4)
	%		(1.52)	(2.55)	(2.92)	(131.93)	(160.65)

* Parentheses indicate negative values.

TSL 1 represents EL 1 for all product classes. At TSL 1, DOE estimates impacts on INPV for residential boiler manufacturers to range from −0.58 percent to −0.09 percent, or a change in INPV of −$2.12 million to −$0.33 million. At this potential standard level, industry free cash flow would be estimated to decrease by approximately 1.52 percent to $26.01 million, compared to the no-new-standards case value of $26.42 million in 2020, the year before the compliance date.

At TSL 1, DOE does not anticipate manufacturers would lose a significant portion of their INPV. This is largely due to the fact that the vast majority of shipments would already meet or exceed the efficiency levels prescribed at TSL 1. Today, approximately 85 percent of residential boiler product listings would meet or exceed the efficiency levels at TSL 1. DOE expects residential boiler manufacturers to incur $1.34 million in product conversion costs for boiler redesign and testing. DOE does not expect the modest efficiency gains at this TSL to require any major product upgrades or capital investments.

At TSL 1, under the preservation of gross margin percentage scenario, the shipment-weighted average MPC increases by approximately 1 percent relative to the no-new-standards case MPC. Manufacturers are able to fully pass on this cost increase to consumers by design in this markup scenario. This slight price increase would not mitigate the $1.34 million in conversion costs estimated at TSL 1, resulting in slightly negative INPV impacts at TSL 1 under the 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. The 1-percent MPC increase is outweighed by a slightly lower average markup and $1.34 million in conversion costs, resulting in small negative impacts at TSL 1.

TSL 2 sets the efficiency level at EL 1 for three product classes (gas-fired steam boilers, gas-fired hot water boilers, and oil-fired steam boilers) and EL 2 for one product classes (oil-fired hot water boilers). At TSL 2, DOE estimates impacts on INPV for residential boiler manufacturers to range from −0.79 percent to 0.24 percent, or a change in INPV of −$2.89 million to $0.86 million. At this potential standard level, industry free cash flow would be estimated to decrease by approximately 2.55 percent to $25.74 million, compared to the no-new-standards case value of $26.42 million in 2020, the year before the compliance date.

DOE does not anticipate manufacturers would lose a substantial portion of their INPV, because a large percentage of shipments would still meet or exceed the efficiency levels prescribed at this TSL. At TSL 2, DOE estimates that today, 74 percent of residential boiler product listings would meet or exceed the efficiency levels analyzed. The drop in the percentage of compliant products is due to the fact that the oil-fired hot water product class would move to EL 2. The non-compliant products would not have a large impact on INPV because oil-fired boilers would only comprise approximately 30 percent of residential boiler shipments in 2021 according to DOE projections, while gas-fired boilers would comprise over 70 percent of shipments.

DOE expects conversion costs would increase, but would still remain small compared to total industry value, as most manufacturers have gas-fired boilers at the prescribed efficiency levels on the market and would only have to make minor changes to their production processes. While the percentage of oil-fired boilers at these efficiency levels on the market is lower, manufacturers did not cite any major investments that would have to be made to reach the efficiency levels at EL 2 for oil-fired hot water products. Manufacturers also pointed out that gas-fired boiler shipments vastly out-pace oil-fired boiler shipments and that the market is continuing to trend towards gas-fired products. Overall, DOE estimates manufacturers would incur $1.60 million in product conversion costs for product redesign and testing and $0.43 million in capital conversion costs to make minor changes to their production lines.

At TSL 2, under the preservation of gross margin percentage scenario, the shipment-weighted average MPC increases by 2 percent relative to the no-new-standards case MPC. In this scenario, INPV impacts are slightly positive because of manufacturers' ability to pass the higher production costs to consumers outweighs the $2.03 million in total conversion costs. Under the preservation of per-unit operating profit markup scenario, the 2-percent MPC increase is outweighed by a slightly lower average markup and $2.03 million in total conversion costs, resulting in minimally negative impacts at TSL 2.

TSL 3 represents EL 1 for one product class (gas-fired steam boilers) and EL 2 for three product classes (oil-fired hot water boilers, gas-fired hot water boilers, and oil-fired steam boilers). At TSL 3, DOE estimates impacts on INPV for residential boiler manufacturers to range from −0.71 percent to 0.44 percent, or a change in INPV of −$2.63 million to $1.62 million. At this potential standard level, industry free cash flow would be estimated to decrease by approximately 2.92 percent in 2020, the year before compliance, to $25.64 million compared to the no-new-standards case value of $26.42 million.

While more significant than the impacts at TSL 2, the impacts on INPV at TSL 3 would still be relatively minor compared to the total industry value. Percentage impacts on INPV would be slightly positive to slightly negative at TSL 3. DOE does not anticipate that manufacturers would lose a significant portion of their INPV at this TSL. While less than the previous TSLs, today, 63 percent of product listings already meet or exceed the efficiency levels prescribed at TSL 3. DOE expects conversion costs to remain small at TSL 3 compared to the total industry value. DOE estimates that product conversion costs would increase as manufacturers would have to redesign a larger percentage of their offerings and may have to design new products to replace lower-efficiency commodity products. At this TSL, DOE estimates that residential boiler manufacturers would incur $1.66 million in product conversion costs. Manufacturers, however, did not cite any major changes that would need to be made to production equipment to achieve the efficiency levels at this TSL. DOE, therefore, estimates that capital conversion costs would remain relatively low at $0.61 million for the industry.

At TSL 3, under the preservation of gross margin percentage markup scenario, the shipment-weighted average MPC increases by 2 percent relative to the no-new-standards case MPC. In this scenario, INPV impacts are slightly positive because manufacturers' ability to pass the higher production costs to consumers outweighs the $2.27 million in total conversion costs. Under the preservation of per-unit operating profit markup scenario, the 2 percent MPC increase is slightly outweighed by a slightly lower average markup and $2.27 million in total conversion costs, resulting in minimally negative to minimally positive impacts at TSL 3.

TSL 4 represents EL 1 for one product class (gas-fired steam boilers), EL 3 for two product classes (oil-fired hot water boilers and oil-fired steam boilers), and EL 4 for one product class (gas-fired hot water boilers). At TSL 4, DOE estimates impacts on INPV for residential boiler manufacturers to range from −22.73 percent to −4.99 percent, or a change in INPV of −$83.61 million to −$18.35 million. At this potential standard level, industry free cash flow would be estimated to decrease by approximately 131.93 percent in the year before compliance (2020) to −$8.43 million relative to the no-new-standards case value of $26.42 million.

Percentage impacts on INPV are moderately to significantly negative at TSL 4. Today, only 27 percent of residential boiler product listings would meet or exceed the efficiency levels at TSL 4. DOE expects that conversion costs would increase significantly at this TSL due to the fact that manufacturers would meet these efficiency levels by using condensing heat exchangers in their gas-fired and oil-fired hot water boiler products.[119] Currently, the majority of gas-fired hot water boilers on the market is made from cast iron, carbon steel, or copper and contains noncondensing heat exchangers, because if these boilers were designed to condense, the acidic condensate from the flue gas would corrode these metals and cause the boiler to fail prematurely. If standards were set where manufacturers of gas-fired hot water boiler products could only meet the efficiency levels with condensing technology, companies that produce their own cast iron sections or their own carbon steel or copper heat exchangers would have to eliminate many of their commodity products, close foundries and casting facilities, and restructure their businesses. Domestic manufacturers who currently offer condensing products import their condensing heat exchangers (constructed from either stainless steel or aluminum) from Europe. DOE believes that if standards were set where manufacturers of gas-fired hot water boiler products could only meet the efficiency levels with condensing technology, some manufacturers may choose to develop their own condensing heat exchanger production capacity in order to gain a cost advantage and remain vertically integrated. This would

[119] At these efficiency levels, manufacturers would also use a condensing heat exchanger for oil-fired hot water boiler products; however, these models are much less common, and DOE believes that the majority of the conversion costs at this TSL would be driven by gas-fired hot water boiler products.

require large capital investments in higher-tech, more-automated production lines and new equipment to handle the different metals that are required. Companies that are currently heavily invested in lower-efficiency products may not be able to make these investments and may choose to exit the market. As noted above, these companies also may choose to source condensing heat exchangers and assemble a product designed around the sourced part, rather than invest in their own heat exchanger production capacity. This strategy would remove a significant piece of the value chain for these companies.

While condensing products and condensing technology are not entirely unfamiliar to the companies that already make condensing products domestically, most manufacturers in the residential boiler industry have relatively little experience in manufacturing the heat exchanger itself. If manufacturers choose to develop their own heat exchanger production capacity, a great deal of testing, prototyping, design, and manufacturing engineering resources will be required to design the heat exchanger and the more advanced control systems found in more-efficient products.

These capital and production conversion expenses lead to the large reduction in cash flow in the years preceding the standard. DOE believes that only a few domestic manufacturers have the resources for this undertaking and believes that some large manufacturers and many smaller manufacturers would continue to source their heat exchangers. Ultimately, DOE estimates that manufacturers would incur $24.53 million in product conversion costs, as some manufacturers would be expected to attempt to add production capacity for condensing heat exchangers and others would have to design baseline products around a sourced condensing heat exchanger. In addition, DOE estimates that manufacturers would incur $61.10 million in capital conversion costs, which would be driven by capital investments in heat exchanger production lines.

At TSL 4, under the preservation of gross margin percentage markup scenario, the shipment-weighted average MPC increases by approximately 30 percent relative to the no-new-standards case MPC. In this scenario, INPV impacts are slightly negative because manufacturers' ability to pass the higher production costs to consumers is slightly outweighed by the $85.63 million in total conversion costs. Under the preservation of per-unit operating profit markup scenario, the 30-percent MPC increase is outweighed by a lower average markup of 1.39 (compared to 1.41 in the preservation of gross margin percentage markup scenario) and $85.63 million in total conversion costs, resulting in significantly negative impacts at TSL 4.

TSL 5 represents EL 2 for one product class (gas-fired steam boilers), EL 3 for two product classes (oil-fired hot water boilers and oil-fired steam boilers), and EL 6 for one product class (gas-fired hot water boilers). TSL 5 represents max-tech for all product classes. At TSL 5, DOE estimates impacts on INPV for residential boiler manufacturers to range from −38.59 percent to −0.30 percent, or a change in INPV of −$141.95 million to −$1.12 million. At this potential standard level, industry free cash flow would be estimated to decrease by approximately 160.65 percent in the year before compliance (2020) to −$16.02 million relative to the no-new-standards case value of $26.42 million.

At TSL 5, percentage impacts on INPV range from slightly negative to significantly negative. Today, only 4 percent of residential boiler product listings would already meet or exceed the efficiency levels prescribed at TSL 5. DOE expects conversion costs to continue to increase at TSL 5, as almost all products on the market would have to be redesigned and new products would have to be developed. As with TSL 4, DOE believes that at these efficiency levels, some manufacturers would choose to develop their own condensing heat exchanger production, rather than continuing to source these components. DOE estimates that product conversion costs would increase to $37.19 million, as manufacturers would have to redesign a larger percentage of their offerings, implement complex control systems, and meet max-tech for all product classes. DOE estimates that manufacturers would incur $69.52 million in capital conversion costs due to some manufacturers choosing to develop their own heat exchanger production and others having to increase the throughput of their existing condensing boiler production lines.

At TSL 5, under the preservation of gross margin percentage markup scenario, the shipment-weighted average MPC increases by approximately 61 percent relative to the no-new-standards case MPC. In this scenario, INPV impacts are negative because manufacturers' ability to pass the higher production costs to consumers is outweighed by the $106.71 million in total conversion costs. Under the preservation of per-unit operating profit markup scenario, the 61-percent MPC increase is outweighed by a lower average markup of 1.36 and $106.71 million in total conversion costs, resulting in significantly negative impacts at TSL 5.

Cash-Flow Analysis Results for Residential Boilers Standby Mode and Off Mode Standards

Standby mode and off mode standards results are presented in Table V.33 and Table V.34. The impacts of standby mode and off mode features were analyzed for the same product classes as the amended AFUE standards, but at different efficiency levels, which correspond to a different set of technology options for reducing standby mode and off mode energy consumption. Therefore, the TSLs in the standby mode and off mode analysis do not correspond to the TSLs in the AFUE analysis. Also, the electric boiler product classes were not analyzed in the GRIM for AFUE standards. As a result, quantitative numbers are also not available for the GRIM analyzing standby mode and off mode standards. However, the standby mode and off mode technology options considered for electric boilers are identical to the technology options for all other residential boiler product classes. Consequently, DOE expects the standby mode and off mode impacts on electric boilers to be of the same order of magnitude as the impacts on all other boiler product classes.

The impacts of standby mode and off mode features were analyzed for the same two markup scenarios to represent the upper and lower bounds of industry impacts for residential boilers that were used in the AFUE analysis: (1) A preservation of gross margin percentage scenario; and (2) a preservation of per-unit operating profit scenario. As with the AFUE analysis, the preservation of gross margin percentage represents the lower bound of impacts, while the preservation of per-unit operating profit scenario represents the upper bound of impacts.

Each of the modeled scenarios in the standby mode and off mode analyses results in a unique set of cash flows and corresponding industry values at each TSL. In the following discussion, the INPV results refer to the difference in industry value between the no-new-standards case and each standards case that results from the sum of discounted cash flows from the base year 2014 through 2050, 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 would 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.33—MANUFACTURER IMPACT ANALYSIS FOR RESIDENTIAL BOILERS FOR STANDBY MODE AND OFF MODE STANDARDS—PRESERVATION OF GROSS MARGIN PERCENTAGE MARKUP SCENARIO *

	Units	No-new-standards case	Trial Standard Level		
			1	2	3
INPV	2014$ millions	367.83	367.73	367.74	368.28
Change in INPV	2014$ millions		(0.10)	(0.09)	0.45
	%		(0.03)	(0.02)	0.12
Product Conversion Costs	2014$ millions		0.21	0.21	0.21
Capital Conversion Costs	2014$ millions.				
Total Conversion Costs	2014$ millions		0.21	0.21	0.21
Free Cash Flow (no-new-standards case = 2019).	2014$ millions	26.42	26.35	26.35	26.35
Change in Free Cash Flow (change from no-new-standards case).	2014$ millions		(0.06)	(0.06)	(0.06)
	%		(0.24)	(0.24)	(0.24)

* Parentheses indicate negative values.

TABLE V.34—MANUFACTURER IMPACT ANALYSIS FOR RESIDENTIAL BOILERS FOR STANDBY MODE AND OFF MODE STANDARDS—PRESERVATION OF PER-UNIT OPERATING PROFIT MARKUP SCENARIO *

	Units	No-new-standards case	Trial Standard Level		
			1	2	3
INPV	2014$ millions	367.83	367.61	367.78	366.12
Change in INPV	2014$ millions		(0.22)	(0.04)	(1.71)
	%		(0.06)	(0.01)	(0.46)
Product Conversion Costs	2014$ millions		0.21	0.21	0.21
Capital Conversion Costs	2014$ millions.				
Total Conversion Costs	2014$ millions		0.21	0.21	0.21
Free Cash Flow (no-new-standards case = 2019).	2014$ millions	26.42	26.35	26.35	26.35
Decrease in Free Cash Flow (change from no-new-standards case).	2014$ millions		(0.06)	(0.06)	(0.06)
	%		(0.24)	(0.24)	(0.24)

* Parentheses indicate negative values.

TSL 1 represents EL 1 for all product classes. At TSL 1, DOE estimates impacts on INPV for residential boiler manufacturers to decrease by less than one tenth of a percent in both markup scenarios, which corresponds to a change in INPV of −$0.22 million to −$0.10 million. At this potential standard level, industry free cash flow is estimated to decrease by approximately 0.24 percent to $26.35 million, compared to the no-new-standards case value of $26.42 million in 2020, the year before the compliance date.

At TSL 1, DOE does not anticipate that manufacturers would lose a significant portion of their INPV. This is largely due to the small incremental costs of standby mode and off mode components relative to the overall costs of residential boiler products. DOE expects residential boiler manufacturers to incur $0.21 million in product conversion costs at TSL 1, primarily for testing. DOE does not expect that manufacturers would incur any capital conversion costs, as the product upgrades will only involve integrating a purchase part.

TSL 2 sets the efficiency level at EL 2 for all product classes. At TSL 2, DOE estimates impacts on INPV for residential boilers manufacturers to range from −0.02 percent to −0.01 percent, or a change in INPV of −$0.09 million to −$0.04 million. At this potential standard level, industry free cash flow is estimated to decrease by approximately 0.24 percent to $26.35 million, compared to the no-new-standards case value of $26.42 million in 2020, the year before the compliance date.

At TSL 2, DOE does not anticipate that manufacturers would lose a significant portion of their INPV. This is largely due to the small incremental costs of standby mode and off mode components relative to the overall costs of residential boiler products. DOE expects residential boiler manufacturers to incur $0.21 million in product conversion costs at TSL 2, primarily for testing. DOE does not expect that manufacturers would incur any capital conversion costs, as the product upgrades will only involve integrating a purchase part.

TSL 3 represents EL 3 for all product classes. At TSL 3, DOE estimates impacts on INPV for residential boiler manufacturers to range from −0.46 percent to 0.12 percent, or a change in INPV of −$1.71 million to $0.45 million. At this potential standard level, industry free cash flow is estimated to decrease by approximately 0.24 percent in the year before compliance to $26.35 million compared to the no-new-standards case value of $26.42 million in 2020, the year before the compliance date.

At TSL 3, DOE does not anticipate that manufacturers would lose a significant portion of their INPV. As with TSLs 1 and 2, this is largely due to the small incremental costs of standby mode and off mode components relative to the overall costs of residential boiler products. DOE expects residential boiler manufacturers to incur $0.21 million in product conversion costs at TSL 3, primarily for testing. DOE does not expect that manufacturers would incur any capital conversion costs, as the product upgrades will only involve integrating a purchase part.

Combining Cash-Flow Analysis Results for Residential Boilers (AFUE Standard and Standby Mode and Off Mode Standard)

As noted in section III.B, DOE analyzed the AFUE standard and the standby mode and off mode standard independently. The AFUE metric accounts for the fossil fuel consumption, whereas the standby mode and off mode metric accounts for the electrical energy use in standby mode and off mode. There are five trial standard levels under consideration for the AFUE standard and three trial stand levels under consideration for the standby mode and off mode standard.

Both the AFUE standard and the standby mode and off mode standard could necessitate changes in manufacturer production costs, as well as conversion cost investments. The assumed design changes for the two standards in the engineering analysis are independent; therefore, changes in manufacturing production costs and the conversion costs are additive. DOE expects that the costs to manufacturers would be mathematically the same regardless of whether or not the standby mode and off mode standards were combined or analyzed separately.

Using the current approach that considers AFUE and standby mode and off mode standards separately, the range of potential impacts of combined standards on INPV is determined by summing the range of potential changes in INPV from the AFUE standard and from the standby mode and off mode standard. Similarly, to estimate the combined conversion costs, DOE sums the estimated conversion costs from the two standards. DOE does not present the combined impacts of all possible combinations of AFUE and standby mode and off mode TSLs in this notice. However, DOE expects the combined impact of the TSLs proposed for AFUE and standby mode and off mode electrical consumption in this final rule to range from −1.18 to 0.56 percent, which is approximately equivalent to a reduction of $4.34 million to an increase of $2.08 million.

b. Impacts on Direct Employment

To quantitatively assess the impacts of energy conservation standards on direct employment in the residential boiler 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 2021. DOE used statistical data from the U.S. Census Bureau's 2011 Annual Survey of Manufacturers (ASM),[120] 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 2011 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 residential boilers, as compared to the no-new-standards case. In general, more-efficient boilers are more complex and more labor intensive and require specialized knowledge about control systems, electronics, and the different metals needed for the heat exchanger. Per-unit labor requirements and production time requirements increase with higher energy conservation standards. As a result, the total labor calculations described in this paragraph (which are generated by the GRIM) are considered an upper bound to direct employment forecasts.

On the other hand, some manufacturers may choose not to make the necessary investments to meet the amended standards for all product classes. Alternatively, they may choose to relocate production facilities where conversion costs and production costs are lower. To establish a lower bound to negative employment impacts, 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. In the case of residential boilers, most manufacturers agreed that higher standards would probably not push their production overseas due to shipping considerations. Rather, high enough standards could force manufacturers to rethink their business models. Instead of vertically integrated manufacturers, they would become assemblers and would source most of their components from overseas. This would mean any workers involved in casting metals that would be corroded in a condensing product would likely lose their jobs. These lower bound estimates were based on GRIM results, conversion cost estimates, and content from manufacturers interviews. The lower bound of employment is presented in Table V.35 below.

DOE estimates that in the absence of amended energy conservation standards, there would be 761 domestic production workers in the residential boiler industry in 2021, the year of compliance. DOE estimates that 90 percent of residential boilers sold in the United States are manufactured domestically. Table V.35 shows the range of the impacts of potential amended energy conservation standards on U.S. production workers of residential boilers.

[120] 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*).

TABLE V.35—POTENTIAL CHANGES IN THE TOTAL NUMBER OF RESIDENTIAL BOILERS PRODUCTION WORKERS IN 2021

	Trial Standard Level *					
	No-new-standards case	1	2	3	4	5
Total Number of Domestic Production Workers in 2021 (without changes in production locations).	761	761 to 770	753 to 773	745 to 775	381 to 898	190 to 958
Potential Changes in Domestic Production Workers in 2021 *.		0 to 9	(8) to 12	(16) to 14	(380) to 137	(571) to 197

* DOE presents a range of potential employment impacts. Numbers in parentheses indicate negative values.

At the upper end of the range, all examined TSLs show positive impacts on domestic employment levels. Producing more-efficient boilers tends to require more labor, and DOE estimates that if residential boiler manufacturers chose to keep their current production in the U.S., domestic employment could increase at each TSL. In interviews, several manufacturers who produce high-efficiency boiler products 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 production processes, as well as metallurgy experts and other workers with experience working with higher-efficiency products. DOE, however, acknowledges that particularly at higher standard levels, manufacturers may not keep their production in the U.S. and also may choose to restructure their businesses or exit the market entirely.

DOE does not expect any significant changes in domestic employment at TSL 1 or TSL 2. Most manufactures 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 small loss of domestic employment at TSL 3 due to the fact that some manufacturers would have to drop their 82-percent-efficient products, except for their gas-fired steam boiler products. Several manufacturers commented that those products were their commodity products and drove a high percentage of their sales. Several manufacturers expressed that they could lose a significant number of employees at TSL 4 and TSL 5, due to the fact that these TSLs contain condensing efficiency levels for the gas-fired hot water boiler product class. These manufacturers have employees who work on production lines that produce cast iron sections and carbon steel or copper heat exchangers for lower to mid-efficiency products. If amended energy conservation standards were to require condensing efficiency levels, these employees would no longer be needed for that function, and manufacturers would have to decide whether to develop their own condensing heat exchanger production, source heat exchangers from Asia or Europe and assemble higher-efficiency products, or leave the market entirely.

DOE notes that its estimates of the impacts on direct employment are based on the analysis of amended AFUE energy efficiency standards only. Standby mode and off mode technology options considered in the engineering analysis would result in component swaps, which would not make the product significantly more complex and would not be difficult to implement. While some product development effort would be required, DOE does not expect the standby mode and off mode standard to meaningfully affect the amount of labor required in production. Consequently, DOE does not anticipate that the proposed standby mode and off mode standards will have a significant impact on direct employment.

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 final rule TSD.

c. Impacts on Manufacturing Capacity

Most residential boiler manufacturers stated that their current production is only running at 50-percent to 70-percent capacity and that any standard that does not propose efficiency levels where manufacturers would use condensing technology for hot water boilers would not have a large effect on capacity. The impacts of a potential condensing standard on manufacturer capacity are difficult to quantify. Some manufacturers who are already making condensing products with a sourced heat exchanger said they would likely be able to increase production using the equipment they already have by utilizing a second shift. Others said a condensing standard would idle a large portion of their business, causing stranded assets and decreased capacity. These manufactures would have to determine how to best increase their condensing boiler production capacity. DOE believes that some larger domestic manufacturers may choose to add production capacity for a condensing heat exchanger production line.

Manufacturers stated that in a scenario where a potential standard would require efficiency levels at which manufacturers would use condensing technology, there is concern about the level of technical resources required to redesign and test all products. The engineering analysis shows that increasingly complex components and control strategies are required as standard levels increase. Manufacturers commented in interviews that the industry would need to add electrical engineering and control systems engineering talent beyond current staffing to meet the redesign requirements of higher TSLs. Additional training might be needed for manufacturing engineers, laboratory technicians, and service personnel if condensing products were broadly adopted. However, because TSL 3 (the adopted level) would not require condensing standards, DOE does not expect manufacturers to face long-term capacity constraints due to the standard levels proposed in this notice.

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 residential boiler 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 500 employees or less for NAICS 333414, ''Heating Equipment (except Warm Air Furnaces) Manufacturing.'' Based on this definition, DOE identified 13 manufacturers in the residential boiler industry that qualify as small businesses. For a discussion of the impacts on the small manufacturer subgroup, see the Regulatory Flexibility Act analysis in section VI.B of this notice and chapter 12 of the final rule 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 appliance efficiency.

For the cumulative regulatory burden analysis, DOE looks at other regulations that could affect residential boiler manufacturers that will take effect approximately three years before or after the 2021 compliance date of amended energy conservation standards for these products. In interviews, manufacturers cited Federal regulations on equipment other than residential boilers that contribute to their cumulative regulatory burden. The compliance years and expected industry conversion costs of relevant amended energy conservation standards are indicated in the Table V.36. DOE has included certain Federal regulations in the Table V.36 that have compliance dates beyond the three-year range of DOE's analysis, because those regulations were cited multiple times by manufacturers in interviews and written comments; they are included here for reference.

TABLE V.36—COMPLIANCE DATES AND EXPECTED CONVERSION EXPENSES OF FEDERAL ENERGY CONSERVATION STANDARDS AFFECTING RESIDENTIAL BOILERS MANUFACTURERS

Federal energy conservation standards	Approximate compliance date	Estimated total industry conversion expense
2007 Residential Furnaces & Boilers 72 FR 65136 (Nov. 19, 2007)	2015	$88M (2006$).*
2011 Residential Furnaces 76 FR 37408 (June 27, 2011); 76 FR 67037 (Oct. 31, 2011).	2015	$2.5M (2009$).**
Commercial Refrigeration Equipment 79 FR 17726 (March 28, 2014)	2017	$184.0M (2012$).
Commercial Packaged Air Conditioners and Heat Pumps.***	2018	TBD.
Commercial Warm-Air Furnaces 80 FR 6182 (Feb. 4, 2015)	2018	$19.9 Million (2013$).
Furnace Fans 79 FR 38130 (July 3, 2014)	2019	$40.6M (2014$).
Single Package Vertical Air Conditioners and Heat Pumps 80 FR 57438 (Sept. 23, 2015).	2019	$9.2M (2014$).
Commercial Water Heaters.***	2019	TBD.
Packaged Terminal Air Conditioners and Heat Pumps † 80 FR 43162 (July 21, 2015).	2019	N/A.
Commercial Packaged Boilers.***	2021	TBD.
Non-weatherized Gas-fired Furnaces and Mobile Home Furnaces.***	2021	TBD.
Direct Heating Equipment/Pool Heaters.***	2021	TBD.
Residential Water Heaters.***	2021	TBD.
Central Air Conditioners.***	2022	TBD.
Room Air Conditioners.***	2022	TBD.
Commercial Packaged Air Conditioning and Heating Equipment (Evaporatively and Water Cooled).***.	2023	TBD.

* Conversion expenses for manufacturers of oil-fired furnaces and gas-fired and oil-fired boilers associated with the November 2007 final rule for residential furnaces and boilers are excluded from this figure. The 2011 direct final rule for residential furnaces sets a higher standard and earlier compliance date for oil furnaces than the 2007 final rule. As a result, manufacturers will be required design to the 2011 direct final rule standard. The conversion costs associated with the 2011 direct final rule are listed separately in this table. EISA 2007 legislated higher standards and earlier compliance dates for residential boilers than were in the November 2007 final rule. As a result, gas-fired and oil-fired boiler manufacturers were required to design to the EISA 2007 standard beginning in 2012. The conversion costs listed for residential gas-fired and oil-fired boilers in the November 2007 residential furnaces and boilers final rule analysis are not included in this figure.

** Estimated industry conversion expenses and approximate compliance date reflect a court-ordered April 24, 2014 remand of the residential non-weatherized and mobile home gas furnaces standards set in the 2011 Energy Conservation Standards for Residential Furnaces and Residential Central Air Conditioners and Heat Pumps. The costs associated with this rule reflect implementation of the amended standards for the remaining furnace product classes (*i.e.,* oil-fired furnaces).

*** 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.

† No conversion costs are expected for packaged terminal air conditioners and heat pumps, as the entire market already meets the standard levels adopted.

Revised DOE Test Procedure for Residential Boilers

In addition to Federal energy conservation standards, DOE identified revisions to the DOE test procedure as another regulatory burdens that would affect manufacturers of residential boilers. On July 28, 2008, DOE published a technical amendment to the 2007 furnaces and boilers final rule, whose purpose was to add design requirements established in the Energy Independence and Security Act of 2007 (EISA 2007). 73 FR 43611. In relevant part, these design requirements mandate the use of an automatic means for adjusting the water temperature for gas-fired hot water boilers, oil-fired hot water boilers, and electric hot water boilers. DOE recently published revisions to its test procedure for residential furnaces and boilers, which in part adopted test methods for verifying the presence of an automatic means for adjusting the water temperature in boilers. (See EERE–2012–BT–TP–0024). Specifically, the January 2016 test procedure includes two test methods to verify the functionality of the automatic means of adjusting the water temperature, which would increase the testing burden for residential boiler manufacturers and thereby the cumulative regulatory burden.

3. National Impact Analysis

a. Significance of Energy Savings

To estimate the energy savings attributable to potential standards for residential boilers, DOE compared their energy consumption under the no-new-standards case to their anticipated energy consumption under each TSL. The savings are measured over the entire lifetime of products purchased in the 30-year period that begins in the year of anticipated compliance with amended standards (2021–2050). Table V.37 presents DOE's projections of the national energy savings for each TSL considered for residential boilers AFUE standards.

Table V.38 present DOE's projections of the national energy savings for each TSL considered for residential boilers standby mode and off mode standards. The savings were calculated using the approach described in section IV.H of this notice.

TABLE V.37—CUMULATIVE NATIONAL ENERGY SAVINGS FOR RESIDENTIAL BOILERS SHIPPED IN 2021–2050: AFUE STANDARDS

Energy savings	Quads				
	Trial Standard Level				
	1	2	3	4	5
Primary energy	0.06	0.09	0.14	0.67	1.38
FFC energy	0.07	0.10	0.16	0.77	1.56

TABLE V.38—CUMULATIVE NATIONAL ENERGY SAVINGS FOR RESIDENTIAL BOILERS SHIPPED IN 2021–2050: STANDBY MODE AND OFF MODE STANDARDS

Energy savings	Quads		
	Trial Standard Level		
	1	2	3
Primary energy	0.0009	0.0012	0.0025
FFC energy	0.0009	0.0013	0.0026

OMB Circular A–4 [121] 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 nine, rather than 30, years of product shipments. The choice of a nine-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.[122] The review timeframe established in EPCA is generally not synchronized with the product lifetime, product manufacturing cycles, or other factors specific to residential boilers. Thus, such results are presented for informational purposes only and are not indicative of any change in DOE's analytical methodology. The NES sensitivity analysis results based on a nine-year analytical period are presented for the AFUE standards in Table V.39.[123] The impacts are counted over the lifetime of residential boilers purchased in 2021–2029.

TABLE V.39—CUMULATIVE NATIONAL ENERGY SAVINGS FOR RESIDENTIAL BOILERS; NINE YEARS OF SHIPMENTS (2021–2029)—AFUE STANDARDS

Energy savings	Quads				
	Trial Standard Level				
	1	2	3	4	5
Primary energy	0.02	0.03	0.05	0.21	0.41
FFC energy	0.02	0.04	0.06	0.25	0.47

[121] 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/*).

[122] Section 325(m) of EPCA requires DOE to review its standards at least once every 6 years, and requires, for certain products, a 3-year period after any new standard is promulgated before compliance is required, except that in no case may any new standards be required within 6 years of the compliance date of the previous standards. While adding a 6-year review to the 3-year compliance period adds up to 9 years, DOE notes that it may undertake reviews at any time within the 6 year period and that the 3-year compliance date may yield to the 6-year backstop. A 9-year analysis period may not be appropriate given the variability that occurs in the timing of standards reviews and the fact that for some consumer products, the compliance period is 5 years rather than 3 years.

[123] DOE presents results based on a nine-year analytical period only for the AFUE standards because the corresponding impacts for the standby mode and off mode TSLs are very small.

b. Net Present Value of Consumer Costs and Benefits

DOE estimated the cumulative NPV of the total costs and savings for consumers that would result from the TSLs considered for residential boilers. In accordance with OMB's guidelines on regulatory analysis,[124] DOE calculated NPV using both a 7-percent and a 3-percent real discount rate. Table V.40 shows the consumer NPV results for each TSL considered for AFUE standards for residential boilers. In each case, the impacts are counted over the lifetime of products purchased in 2021–2050.

TABLE V.40—CUMULATIVE NET PRESENT VALUE OF CONSUMER BENEFITS FOR RESIDENTIAL BOILERS SHIPPED IN 2021–2050—AFUE STANDARDS

Discount rate (%)	Billion 2014$				
	Trial Standard Level				
	1	2	3	4	5
3	0.471	0.852	1.198	0.082	0.597
7	0.134	0.237	0.350	(1.349)	(2.127)

Note: Parentheses indicate negative values.

Table V.41 shows the consumer NPV results for each standby mode and off mode TSL considered for residential boilers. In each case, the impacts cover the lifetime of products purchased in 2021–2050.

TABLE V.41—CUMULATIVE NET PRESENT VALUE OF CONSUMER BENEFITS FOR RESIDENTIAL BOILERS SHIPPED IN 2021–2050—STANDBY MODE AND OFF MODE STANDARDS

Discount rate (%)	Billion 2014$		
	Trial Standard Level		
	1	2	3
3	0.007	0.004	0.014
7	0.002	(0.00005)	0.003

Note: Parentheses indicate negative values.

The NPV results based on the aforementioned 9-year analytical period are presented in Table V.42 for AFUE standards. The impacts are counted over the lifetime of products purchased in 2021–2029. 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.42—CUMULATIVE NET PRESENT VALUE OF CONSUMER BENEFITS FOR RESIDENTIAL BOILERS; NINE YEARS OF SHIPMENTS (2021–2029): AFUE STANDARDS

Discount rate (%)	Billion 2014$				
	Trial Standard Level				
	1	2	3	4	5
3	0.179	0.325	0.462	(0.613)	(0.731)
7	0.065	0.114	0.173	(1.028)	(1.537)

Note: Parentheses indicate negative values.

The above results reflect the use of a constant price trend (reference case) to estimate the future prices for residential boilers over the analysis period (see section IV.H of this document). DOE also conducted a sensitivity analysis that considered one scenario with an increasing price trend than the reference case and one scenario with a decreasing price trend. The results of these alternative cases are presented in appendix 10C of the final rule TSD. In the increasing price trend case, the NPV of consumer benefits is lower than in the reference case. In the decreasing price trend case, the NPV of consumer benefits is higher than in the reference case.

c. Indirect Impacts on Employment

DOE expects energy conservation standards for residential boilers to reduce energy bills for consumers of those products, with the resulting net savings being redirected to other forms of economic activity. These expected shifts in spending and economic activity could affect the demand for labor. As described in section IV.N, 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

[124] U.S. Office of Management and Budget, "Circular A–4: Regulatory Analysis," section E, (Sept. 17, 2003) (Available at: *http://www.whitehouse.gov/omb/circulars_a004_a-4/*).

years of the analysis. Therefore, DOE generated results for near-term time frames (2021 to 2026), where these uncertainties are reduced.

The results suggest that the adopted standards are likely to have a negligible impact on the net demand for labor in the economy. The net change in jobs is so small that it would be imperceptible in national labor statistics and might be offset by other, unanticipated effects on employment. Chapter 16 of the final rule TSD presents detailed results regarding anticipated indirect employment impacts.

4. Impact on Utility or Performance of Products

DOE has concluded that the amended standards adopted in this final rule would not reduce the utility or performance of the residential boilers under consideration in this rulemaking. Manufacturers of these products currently offer units that meet or exceed the adopted standards.

5. Impact of Any Lessening of Competition

As discussed in section III.E.1.e, DOE considered any lessening of competition that is likely to result from new or amended standards. The Attorney General of the United States (Attorney General) determines the impact, if any, of any lessening of competition likely to result from a proposed standard and transmits such determination in writing to the Secretary, together with an analysis of the nature and extent of such impact. To assist the Attorney General in making such determination, DOE provided the Department of Justice (DOJ) with copies of the NOPR and the TSD for review. In its assessment letter responding to DOE, DOJ concluded that the proposed energy conservation standards for residential boilers are unlikely to have a significant adverse impact on competition. DOE is publishing the Attorney General's assessment at the end of this final rule.

6. Need of the Nation To Conserve Energy

Enhanced energy efficiency, where economically justified, improves the Nation's energy security, strengthens the economy, and reduces the environmental impacts (costs) of energy production. Energy conservation resulting from amended AFUE and new standby mode and off mode standards for residential boilers is expected to yield environmental benefits in the form of reduced emissions of air pollutants and greenhouse gases. As a measure of this reduced demand, chapter 15 in the final rule TSD presents the estimated reduction in generating capacity, relative to the no-new-standards case, for the TSLs that DOE considered in this rulemaking.

Table V.43 and Table V.44 provide DOE's estimate of cumulative emissions reductions expected to result from the TSLs considered in this rulemaking for AFUE standards and standby mode and off mode standards, respectively. The tables include site and power sector emissions and upstream emissions. The emissions were calculated using the multipliers discussed in section IV.K. DOE reports annual emissions reductions for each TSL in chapter 13 of the final rule TSD.

As noted in section IV.K, the estimated CO_2 emissions reductions do not account for the effects of the Clean Power Plan (CPP). Including the CPP would have a negligible effect on the CO_2 emissions reduction estimated to result from the adopted AFUE standards for residential boilers, however, as the power sector accounts for only 0.9 percent of the CO_2 emissions reduction. The impact on the CO_2 emissions reduction estimated to result from the adopted standards for standby mode and off mode would be much larger, as the reduction is nearly all from power sector emissions. Under the CPP, the value of CO_2 emissions reductions for the adopted standby mode and off mode standards would be considerably lower—perhaps by as much as one third. Such reduction would not affect the decision to adopt TSL 3 for standby mode and off mode standards, however.

TABLE V.43—CUMULATIVE EMISSIONS REDUCTION FOR RESIDENTIAL BOILERS SHIPPED IN 2021–2050: AFUE STANDARDS

	Trial Standard Level				
	1	2	3	4	5
Site and Power Sector Emissions*					
CO_2 (million metric tons)	3.38	5.53	8.14	37.70	75.50
SO_2 (thousand tons)	0.672	1.84	1.94	2.40	3.45
NO_X (thousand tons)	37.9	98.4	105	355	408
Hg (lbs)	(0.0312)	0.125	0.342	(28.1)	(21.8)
CH_4 (thousand tons)	0.084	0.157	0.216	0.502	1.382
N_2O (thousand tons)	0.031	0.076	0.084	0.228	0.321
Upstream Emissions					
CO_2 (million metric tons)	0.497	0.821	1.19	6.06	11.41
SO_2 (thousand tons)	0.046	0.125	0.131	0.362	0.402
NO_X (thousand tons)	7.37	11.5	17.4	92.2	178
Hg (lbs)	0.0368	0.103	0.108	0.0512	0.115
CH_4 (thousand tons)	32.6	37.2	71.7	452	964
N_2O (thousand tons)	0.002	0.006	0.006	0.022	0.032
Total FFC Emissions					
CO_2 (million metric tons)	3.88	6.35	9.33	43.76	86.90
SO_2 (thousand tons)	0.718	1.97	2.07	2.76	3.85
NO_X (thousand tons)	45.3	110	122	447	586
Hg (lbs)	0.00561	0.227	0.450	(28.1)	(21.7)
CH_4 (thousand tons)	32.7	37.4	71.9	452	965
CH_4 (thousand tons CO_2eq)**	914	1,046	2,013	12,662	27,023
N_2O (thousand tons)	0.033	0.082	0.091	0.249	0.352

TABLE V.43—CUMULATIVE EMISSIONS REDUCTION FOR RESIDENTIAL BOILERS SHIPPED IN 2021–2050: AFUE STANDARDS—Continued

	Trial Standard Level				
	1	2	3	4	5
N_2O (thousand tons CO_2eq) **	8.73	21.7	24.0	66.0	93.3

* Primarily site emissions. Values include the increase in power sector emissions from higher electricity use at TSLs 4 and 5.
** CO_2eq is the quantity of CO_2 that would have the same global warming potential (GWP). Negative values refer to an increase in emissions.
Note: Parentheses indicate negative values.

TABLE V.44—CUMULATIVE EMISSIONS REDUCTION FOR RESIDENTIAL BOILERS SHIPPED IN 2021–2050: STANDBY MODE AND OFF MODE STANDARDS

	Trial Standard Level		
	1	2	3
Site and Power Sector Emissions			
CO_2 (million metric tons)	0.052	0.072	0.144
SO_2 (thousand tons)	0.031	0.043	0.085
NO_X (thousand tons)	0.057	0.080	0.160
Hg (lbs)	0.227	0.318	0.636
CH_4 (thousand tons)	0.004	0.006	0.012
N_2O (thousand tons)	0.001	0.001	0.002
Upstream Emissions			
CO_2 (million metric tons)	0.003	0.004	0.008
SO_2 (thousand tons)	0.001	0.001	0.002
NO_X (thousand tons)	0.042	0.059	0.119
Hg (lbs)	0.00236	0.00331	0.00662
CH_4 (thousand tons)	0.234	0.328	0.656
N_2O (thousand tons)	0.000	0.000	0.000
Total FFC Emissions			
CO_2 (million metric tons)	0.055	0.076	0.153
SO_2 (thousand tons)	0.031	0.043	0.087
NO_X (thousand tons)	0.099	0.139	0.278
Hg (lbs)	0.229	0.321	0.642
CH_4 (thousand tons)	0.239	0.334	0.669
CH_4 (thousand tons CO_2eq) *	6.69	9.36	18.7
N_2O (thousand tons)	0.001	0.001	0.002
N_2O (thousand tons CO_2eq) *	0.172	0.240	0.481

* CO_2eq is the quantity of CO_2 that would have the same global warming potential (GWP).

As part of the analysis for this final rule, DOE estimated monetary benefits likely to result from the reduced emissions of CO_2 and NO_X that DOE estimated for each of the considered TSLs for residential boilers. As discussed in section IV.L of this document, for CO_2, DOE used the most recent values for the SCC developed by an interagency process. The four sets of SCC values for CO_2 emissions reductions in 2015 resulting from that process (expressed in 2014$) are represented by $12.2/metric ton (the average value from a distribution that uses a 5-percent discount rate), $40.0/metric ton (the average value from a distribution that uses a 3-percent discount rate), $62.3/metric ton (the average value from a distribution that uses a 2.5-percent discount rate), and $117/metric ton (the 95th-percentile value from a distribution that uses a 3-percent discount rate). The values for later years are higher due to increasing damages (public health, economic, and environmental) as the projected magnitude of climate change increases.

Table V.45 presents the global value of CO_2 emissions reductions at each TSL for AFUE standards. Table V.46 presents the global value of CO_2 emissions reductions at each TSL for standby mode and off mode standards. For each of the four cases, DOE calculated a present value of the stream of annual values using the same discount rate as was used in the studies upon which the dollar-per-ton values are based. DOE calculated domestic values as a range from 7 percent to 23 percent of the global values; these results are presented in chapter 14 of the final rule TSD.

TABLE V.45—ESTIMATES OF GLOBAL PRESENT VALUE OF CO_2 EMISSIONS REDUCTION FOR RESIDENTIAL BOILERS SHIPPED IN 2021–2050: AFUE STANDARDS

TSL	SCC case* (Million 2014$)			
	5% discount rate, average	3% discount rate, average	2.5% discount rate, average	3% discount rate, 95th percentile
Site and Power Sector Emissions**				
1	19.1	95.1	154	290
2	31.5	156	253	477
3	46.2	229	371	700
4	198	1,018	1,659	3,113
5	399	2,041	3,325	6,235
Upstream Emissions				
1	2.82	14.0	22.7	42.7
2	4.68	23.2	37.5	70.8
3	6.78	33.6	54.4	103
4	32.2	165	268	503
5	60.5	309	503	944
Total FFC Emissions				
1	22.0	109	176	333
2	36.2	179	290	548
3	53.0	263	425	802
4	230	1,183	1,927	3,616
5	459	2,350	3,828	7,180

* 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.,* not CO_2eq of other greenhouse gases).
** Includes the increase in power sector emissions from higher electricity use at TSLs 4 and 5.

TABLE V.46—ESTIMATES OF GLOBAL PRESENT VALUE OF CO_2 EMISSIONS REDUCTION FOR RESIDENTIAL BOILERS SHIPPED IN 2021–2050: STANDBY MODE AND OFF MODE STANDARDS

TSL	SCC Case* (Million 2014$)			
	5% discount rate, average	3% discount rate, average	2.5% discount rate, average	3% discount rate, 95th percentile
Site and Power Sector Emissions				
1	0.287	1.43	2.32	4.37
2	0.401	2.01	3.25	6.12
3	0.803	4.01	6.50	12.2
Upstream Emissions				
1	0.016	0.081	0.132	0.249
2	0.023	0.114	0.185	0.348
3	0.045	0.228	0.370	0.696
Total FFC Emissions				
1	0.303	1.51	2.46	4.62
2	0.424	2.12	3.44	6.47
3	0.848	4.24	6.87	12.9

* 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.,* not CO_2eq of other greenhouse gases).

DOE is well aware that scientific and economic knowledge about the contribution of CO_2 and other GHG emissions to changes in the future global climate and the potential resulting damages to the world economy continues to evolve rapidly. Thus, any value placed on reduced CO_2 emissions in this rulemaking 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 final rule 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 residential boilers. The dollar-per-ton values that DOE used is discussed in section IV.L of this document. Table V.47 presents the cumulative present values for NO_X emissions for each AFUE TSL calculated using seven-percent and three-percent discount rates. Table V.48 presents the cumulative present values for NO_X emissions for each standby mode and off mode TSL calculated using seven-percent and three-percent discount rates.

TABLE V.47—ESTIMATES OF PRESENT VALUE OF NO_X EMISSIONS REDUCTION FOR RESIDENTIAL BOILERS SHIPPED IN 2021–2050: AFUE STANDARDS *

TSL	Million 2014$	
	3% discount rate	7% discount rate
Site and Power Sector Emissions **		
1	101	33.3
2	264	87.6
3	282	93.8
4	801	184
5	932	224
Upstream Emissions		
1	19.5	6.5
2	30.6	10.2
3	46.1	15.4
4	228	67.5
5	437	131
Total FFC Emissions †		
1	121	39.8
2	294	97.8
3	328	109
4	1,029	251
5	1,369	354

* The results reflect use of the low benefits per ton values.
** Includes the increase in power sector emissions from higher electricity use at TSLs 4 and 5.
† Components may not sum to total due to rounding.

TABLE V.48—ESTIMATES OF PRESENT VALUE OF NO_X EMISSIONS REDUCTION FOR RESIDENTIAL BOILERS SHIPPED IN 2021–2050: STANDBY MODE AND OFF MODE STANDARDS *

TSL	Million 2014$	
	3% discount rate	7% discount rate
Site and Power Sector Emissions		
1	0.147	0.048
2	0.206	0.067
3	0.411	0.134
Upstream Emissions		
1	0.108	0.034
2	0.151	0.048
3	0.302	0.096
Total FFC Emissions **		
1	0.255	0.082
2	0.357	0.115
3	0.713	0.231

* The results reflect use of the low benefits per ton values.
** Components may not sum to total due to rounding.

7. Other Factors

The Secretary of Energy, in determining whether a standard is economically justified, may consider any other factors that the Secretary deems to be relevant. (42 U.S.C. 6295(o)(2)(B)(i)(VII)) No other factors were considered in this analysis.

8. Summary of National Economic Impacts

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.49 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 AFUE TSL considered in this rulemaking, at both a seven-percent and three-percent discount rate.

Table V.50 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 standby mode and off mode TSL considered in this rulemaking, at both a seven-percent and three-percent discount rate. The CO_2 values used in the columns of each table correspond to the four sets of SCC values discussed above.

TABLE V.49—NET PRESENT VALUE OF CONSUMER SAVINGS COMBINED WITH PRESENT VALUE OF MONETIZED BENEFITS FROM CO_2 AND NO_X EMISSIONS REDUCTIONS: AFUE STANDARDS

TSL	Consumer NPV at 3% discount rate added with:			
	SCC Case* $12.2/metric ton and NO_X value at 3% discount rate	SCC Case* $40.0/metric ton and NO_X value at 3% discount rate	SCC Case* $62.3/metric ton and NO_X value at 3% discount rate	SCC Case* $117/metric ton and NO_X Value at 3% discount rate
	Billion 2014$			
1	0.614	0.701	0.768	0.925
2	1.183	1.326	1.437	1.694
3	1.579	1.789	1.951	2.328
4	1.341	2.294	3.038	4.726
5	2.425	4.316	5.794	9.145
TSL	Consumer NPV at 7% Discount Rate added with:			
	SCC Case* $12.2/metric ton and NO_X Value at 7% discount rate	SCC Case* $40.0/metric ton and NO_X Value at 7% discount rate	SCC Case* $62.3/metric ton and NO_X Value at 7% discount rate	SCC Case* $117/metric ton and NO_X Value at 7% discount rate
	Billion 2014$			
1	0.196	0.283	0.350	0.506
2	0.371	0.515	0.625	0.883
3	0.512	0.722	0.884	1.261
4	(0.867)	0.086	0.830	2.519
5	(1.314)	0.577	2.055	5.407

*These label values represent the global SCC in 2015, in 2014$. For NO_X emissions, to calculate present value of the total monetary sum from reduced NO_X emissions, DOE applied real discount rates of 3 percent and 7 percent to the appropriate $/ton value listed in chapter 14 of the final rule TSD.

Note: Parentheses indicate negative values.

TABLE V.50—NET PRESENT VALUE OF CONSUMER SAVINGS COMBINED WITH PRESENT VALUE OF MONETIZED BENEFITS FROM CO_2 AND NO_X EMISSIONS REDUCTIONS: STANDBY MODE AND OFF MODE STANDARDS

TSL	Consumer NPV at 3% Discount Rate added with:			
	SCC Case* $12.2/metric ton and NO_X Value at 3% discount rate	SCC Case* $40.0/metric ton and NO_X Value at 3% discount rate	SCC Case* $62.3/metric ton and NO_X Value at 3% discount rate	SCC Case* $117/metric ton and NO_X Value at 3% discount rate
	Billion 2014$			
1	0.008	0.009	0.010	0.012
2	0.004	0.006	0.007	0.010
3	0.015	0.019	0.021	0.028

TABLE V.50—NET PRESENT VALUE OF CONSUMER SAVINGS COMBINED WITH PRESENT VALUE OF MONETIZED BENEFITS FROM CO_2 AND NO_X EMISSIONS REDUCTIONS: STANDBY MODE AND OFF MODE STANDARDS—Continued

TSL	Consumer NPV at 7% Discount Rate added with:			
	SCC Case* $12.2/metric ton and NO_X Value at 7% discount rate	SCC Case* $40.0/metric ton and NO_X Value at 7% discount rate	SCC Case* $62.3/metric ton and NO_X Value at 7% discount rate	SCC Case* $117/metric ton and NO_X Value at 7% discount rate
	Billion 2014$			
1	0.003	0.004	0.005	0.007
2	0.000	0.002	0.004	0.007
3	0.004	0.008	0.010	0.017

*These label values represent the global SCC in 2015, in 2014$. For NO_X emissions, to calculate present value of the total monetary sum from reduced NO_X emissions, DOE applied real discount rates of 3 percent and 7 percent to the appropriate $/ton value listed in chapter 14 of the final rule TSD.

In considering the above results, two issues are relevant. First, the national operating cost savings are domestic U.S. 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 different time frames for analysis. The national operating cost savings is measured for the lifetime of products shipped in 2021–2050. Because CO_2 emissions have a very long residence time in the atmosphere,[125] the SCC values in future years reflect the present value of future climate-related impacts that continue beyond 2100.

C. Conclusion

When considering standards, the new or amended energy conservation standards that DOE adopts for any type (or class) of covered product, including residential boilers, must be designed to achieve the maximum improvement in energy efficiency that the Secretary determines is technologically feasible and economically justified. (42 U.S.C. 6295(o)(2)(A)) In determining whether a standard is economically justified, the Secretary must determine whether the benefits of the standard exceed its burdens by, to the greatest extent practicable, considering the seven statutory factors discussed previously. (42 U.S.C. 6295(o)(2)(B)(i)) The new or amended standard must also result in significant conservation of energy. (42 U.S.C. 6295(o)(3)(B))

For this final rule, DOE considered the impacts of amended standards for residential boilers at each TSL, beginning with the maximum technologically feasible level, to determine whether that level was economically justified. Where the max-tech level was not justified, DOE then considered the next most efficient level and undertook the same evaluation until it reached the highest efficiency level that is both technologically feasible and economically justified and saves a significant amount of energy.

To aid the reader as DOE discusses the benefits and/or burdens of each TSL, tables in this section present a summary of the results of DOE's quantitative analysis for each TSL. In addition to the quantitative results presented in the tables, DOE also considers other burdens and benefits that affect economic justification. These include the impacts on identifiable subgroups of consumers who may be disproportionately affected by a national standard and impacts on employment.

DOE also notes that the economics literature provides a wide-ranging discussion of how consumers trade off upfront costs and energy savings in the absence of government intervention. Much of this literature attempts to explain why consumers appear to undervalue energy efficiency improvements. There is evidence that consumers undervalue future energy savings as a result of: (1) A lack of information; (2) a lack of sufficient salience of the long-term or aggregate benefits; (3) a lack of sufficient savings to warrant delaying or altering purchases; (4) excessive focus on the short term, in the form of inconsistent weighting of future energy cost savings relative to available returns on other investments; (5) computational or other difficulties associated with the evaluation of relevant tradeoffs; and (6) a divergence in incentives (for example, between renters and owners, or builders and purchasers). Having less than perfect foresight and a high degree of uncertainty about the future, consumers may trade off these types of investments at a higher than expected rate between current consumption and uncertain future energy cost savings. 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).

In DOE's current regulatory analysis, potential changes in the benefits and costs of a regulation due to changes in consumer purchase decisions are included in two ways. First, if consumers forego the purchase of a product in the standards case, this decreases sales for product manufacturers, and the impact on manufacturers attributed to lost revenue is included in the MIA. Second, DOE accounts for energy savings attributable only to products actually used by consumers in the standards case; if a regulatory option decreases the number of products purchased by consumers, this decreases the potential energy savings from an energy conservation standard. DOE provides estimates of shipments and changes in the volume of product purchases in chapter 9 of the final rule TSD. However, DOE's current analysis does not explicitly control for

[125] 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).

heterogeneity in consumer preferences, preferences across subcategories of products or specific features, or consumer price sensitivity variation according to household income.[126]

While DOE is not prepared at present to provide a fuller quantifiable framework for estimating the benefits and costs of changes in consumer purchase decisions due to an energy conservation standard, DOE is committed to developing a framework that can support empirical quantitative tools for improved assessment of the consumer welfare impacts of appliance standards. DOE has posted a paper that discusses the issue of consumer welfare impacts of appliance energy conservation standards, and potential enhancements to the methodology by which these impacts are defined and estimated in the regulatory process.[127] DOE welcomes comments on how to more fully assess the potential impact of energy conservation standards on consumer choice and how to quantify this impact in its regulatory analysis in future rulemakings.

1. Benefits and Burdens of Trial Standard Levels Considered for Residential Boilers for AFUE Standards

Table V.51 and Table V.52 summarize the quantitative impacts estimated for each AFUE TSL for residential boilers. The national impacts are measured over the lifetime of residential boilers purchased in the 30-year period that begins in the anticipated year of compliance with amended standards (2021–2050). The energy savings, emissions reductions, and value of emissions reductions refer to full-fuel-cycle results. The efficiency levels contained in each TSL are described in section V.A of this notice.

TABLE V.51—SUMMARY OF ANALYTICAL RESULTS FOR RESIDENTIAL BOILERS AFUE TSLs: NATIONAL IMPACTS

Category	Trial Standard Level				
	1	2	3	4	5
Cumulative FFC Energy Savings (quads)	0.07	0.10	0.16	0.77	1.56.
NPV of Consumer Costs and Benefits (2014$ billion)					
3% discount rate	0.471	0.852	1.198	0.082	0.597.
7% discount rate	0.134	0.237	0.350	(1.349)	(2.127).
Cumulative FFC Emissions Reduction*					
CO_2 (*million metric tons*)	3.88	6.35	9.33	43.76	86.90.
SO_2 (*thousand tons*)	0.718	1.97	2.07	2.76	3.85.
NO_X (*thousand tons*)	45.3	110	122	447	586.
Hg (*lbs*)	0.00561	0.227	0.450	(28.1)	(21.7).
CH_4 (*thousand tons*)	32.7	37.4	71.9	452	965.
CH_4 (*thousand tons CO_2eq*)**	914	1,046	2,013	12,662	27,023.
N_2O (*thousand tons*)	0.033	0.082	0.091	0.249	0.352.
N_2O (*thousand tons CO_2eq*)**	8.73	21.7	24.0	66.0	93.3.
Value of Emissions Reduction (Cumulative FFC Emissions)					
CO_2 (2014$ million)†	22.0 to 333	36.2 to 548	53.0 to 802	230 to 3,616	459 to 7,180.
NO_X—3% discount rate (2014$ million)	121 to 266	294 to 648	328 to 722	1029 to 2235	1369 to 2982.
NO_X—7% discount rate (2014$ million)	39.8 to 89.1	97.8 to 219	109 to 244	251 to 566	354 to 796.

* Includes the increase in power sector emissions from higher electricity use at TSLs 4 and 5.
** 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.52—SUMMARY OF ANALYTICAL RESULTS FOR RESIDENTIAL BOILERS AFUE TSLs: MANUFACTURER AND CONSUMER IMPACTS

Category	Trial Standard Level				
	1	2	3	4	5
Manufacturer Impacts					
Industry NPV (2014$ million) (Base Case INPV = 367.83).	365.70 to 367.50	364.94 to 368.69	365.20 to 369.45	284.21 to 349.47	225.88 to 366.71.
Industry NPV (*$ change*)	(2.12) to (0.33)	(2.89) to 0.86	(2.63) to 1.62	(83.61) to (18.35)	(141.95) to (1.12).
Industry NPV (*% change*)	(0.58) to (0.09)	(0.79) to 0.24	(0.71) to 0.44	(22.73) to (4.99)	(38.59) to (0.30).
Consumer Average LCC Savings (2014$)					
Gas-fired Hot Water Boiler	210	210	364	632	303.
Gas-fired Steam Boiler	333	333	333	333	207.

[126] P.C. Reiss and M.W. White, Household Electricity Demand, Revisited, *Review of Economic Studies* (2005) 72, 853–883.

[127] Alan Sanstad, Notes on the Economics of Household Energy Consumption and Technology Choice, Lawrence Berkeley National Laboratory (2010) (Available at: *http://www1.eere.energy.gov/buildings/appliance_standards/pdfs/consumer_ee_theory.pdf*).

TABLE V.52—SUMMARY OF ANALYTICAL RESULTS FOR RESIDENTIAL BOILERS AFUE TSLS: MANUFACTURER AND CONSUMER IMPACTS—Continued

Category	Trial Standard Level				
	1	2	3	4	5
Oil-fired Hot Water Boiler	260	626	626	192	192.
Oil-fired Steam Boiler	400	400	434	505	505.
Shipment-Weighted Average *	235	315	420	510	276.
Consumer Simple PBP (years)					
Gas-fired Hot Water Boiler	1.2	1.2	1.2	8.4	11.8.
Gas-fired Steam Boiler	2.7	2.7	2.7	2.7	10.7.
Oil-fired Hot Water Boiler	6.9	5.8	5.8	16.5	16.5.
Oil-fired Steam Boiler	6.6	6.6	6.7	7.8	7.8.
Shipment-Weighted Average *	2.7	2.4	2.4	9.7	12.7.
Percentage of Consumers that Experience a Net Cost					
Gas-fired Hot Water Boiler	0.3%	0.3%	0.4%	21.9%	55.5%.
Gas-fired Steam Boiler	0.9%	0.9%	0.9%	0.9%	30.8%.
Oil-fired Hot Water Boiler	10.4%	8.8%	8.8%	58.9%	58.9%.
Oil-fired Steam Boiler	11.9%	11.9%	19.7%	34.2%	34.2%.
Shipment-Weighted Average *	2.8%	2.5%	2.7%	28.5%	53.8%.

Note: Parentheses indicate negative values.
* Weighted by shares of each product class in total projected shipments in 2021.

DOE first considered TSL 5, which represents the max-tech efficiency levels. TSL 5 would save an estimated 1.6 quads of energy, an amount DOE considers significant. Under TSL 5, the NPV of consumer benefit would be $−2.127 billion using a discount rate of 7 percent, and $0.597 billion using a discount rate of 3 percent.

The cumulative emissions reductions at TSL 5 are 86.90 Mt of CO_2, 3.85 thousand tons of SO_2, 586 thousand tons of NO_X, −21.7 lbs of Hg, 965 thousand tons of CH_4, and 0.352 thousand tons of N_2O. The estimated monetary value of the CO_2 emissions reduction at TSL 5 ranges from $459 million to $7,180 million.

At TSL 5, the average LCC impact is a savings of $303 for gas-fired hot water boilers, $207 for gas-fired steam boilers, $192 for oil-fired hot water boilers, and $505 for oil-fired steam boilers. The simple payback period is 11.8 years for gas-fired hot water boilers, 10.7 years for gas-fired steam boilers, 16.5 years for oil-fired hot water boilers, and 7.8 years for oil-fired steam boilers. The share of consumers experiencing a net LCC cost is 55.5 percent for gas-fired hot water boilers, 30.8 percent for gas-fired steam boilers, 58.9 percent for oil-fired hot water boilers, and 34.2 percent for oil-fired steam boilers.

At TSL 5, the projected change in INPV ranges from a decrease of $141.95 million to a decrease of $1.12 million. If the decrease of $141.95 million were to occur, TSL 5 could result in a net loss of 38.59 percent in INPV to manufacturers of covered residential boilers.

The Secretary concludes that at TSL 5 for residential boilers, the benefits of energy savings, positive NPV of consumer benefits at a 3-percent discount rate, emission reductions, and the estimated monetary value of the emissions reductions would be outweighed by the negative NPV of consumer benefits at a 7-percent discount rate, the economic burden on some consumers, and the impacts on manufacturers, including the conversion costs and profit margin impacts that could result in a large reduction in INPV. Consequently, the Secretary has concluded that TSL 5 is not economically justified.

DOE then considered TSL 4. TSL 4 would save an estimated 0.77 quads of energy, an amount DOE considers significant. Under TSL 4, the NPV of consumer benefit would be $−1.349 billion using a discount rate of 7 percent, and $0.082 billion using a discount rate of 3 percent.

The cumulative emissions reductions at TSL 4 are 43.76 Mt of CO_2, 2.76 thousand tons of SO_2, 447 thousand tons of NO_X, −28.1 lbs of Hg, 452 thousand tons of CH_4, and 0.249 thousand tons of N_2O. The estimated monetary value of the CO_2 emissions reduction at TSL 4 ranges from $230 million to $3,616 million.

At TSL 4, the average LCC impact is a savings of $632 for gas-fired hot water boilers, $333 for gas-fired steam boilers, $192 for oil-fired hot water boilers, and $505 for oil-fired steam boilers. The simple payback period is 8.4 years for gas-fired hot water boilers, 2.7 years for gas-fired steam boilers, 16.5 years for oil-fired hot water boilers, and 7.8 years for oil-fired steam boilers. The share of consumers experiencing a net LCC cost is 21.9 percent for gas-fired hot water boilers, 0.9 percent for gas-fired steam boilers, 58.9 percent for oil-fired hot water boilers, and 34.2 percent for oil-fired steam boilers.

At TSL 4, the projected change in INPV ranges from a decrease of $83.61 million to a decrease of $18.35 million. If the decrease of $83.61 million were to occur, TSL 4 could result in a net loss of 22.73 percent in INPV to manufacturers of covered residential boilers.

The Secretary concludes that at TSL 4 for residential boilers, the benefits of energy savings, positive NPV of consumer benefits at a 3-percent discount rate, emission reductions, and the estimated monetary value of the emissions reductions would be outweighed by the negative NPV of consumer benefits at a 7-percent discount rate, the economic burden on some consumers, and the impacts on manufacturers, including the conversion costs and profit margin impacts that could result in a large reduction in INPV. Consequently, the Secretary has concluded that TSL 4 is not economically justified.

DOE then considered TSL 3. TSL 3 would save an estimated 0.16 quads of energy, an amount DOE considers significant. Under TSL 3, the NPV of consumer benefit would be $0.350

billion using a discount rate of 7 percent, and $1.198 billion using a discount rate of 3 percent.

The cumulative emissions reductions at TSL 3 are 9.33 Mt of CO_2, 2.07 thousand tons of SO_2, 122 thousand tons of NO_X, 0.450 lbs of Hg, 71.9 thousand tons of CH_4, and 0.091 thousand tons of N_2O. The estimated monetary value of the CO_2 emissions reduction at TSL 3 ranges from $53.0 million to $802 million.

At TSL 3, the average LCC impact is a savings of $364 for gas-fired hot water boilers, $333 for gas-fired steam boilers, $626 for oil-fired hot water boilers, and $434 for oil-fired steam boilers. The simple payback period is 1.2 years for gas-fired hot water boilers, 2.7 years for gas-fired steam boilers, 5.8 years for oil-fired hot water boilers, and 6.7 years for oil-fired steam boilers. The share of consumers experiencing a net LCC cost is 0.4 percent for gas-fired hot water boilers, 0.9 percent for gas-fired steam boilers, 8.8 percent for oil-fired hot water boilers, and 19.7 percent for oil-fired steam boilers.

At TSL 3, the projected change in INPV ranges from a decrease of $2.63 million to an increase of $1.62 million. If the decrease of $2.63 million were to occur, TSL 3 could result in a net loss of 0.71 percent in INPV to manufacturers of covered residential boilers.

After considering the analysis and weighing the benefits and the burdens, the Secretary has concluded that at TSL 3 for residential boilers, the benefits of energy savings, positive NPV of consumer benefit at both 3-percent and 7-percent discount rates, emission reductions, the estimated monetary value of the emissions reductions, and positive average LCC savings would outweigh the negative impacts on some consumers and on manufacturers, including the conversion costs that could result in a reduction in INPV for manufacturers. Accordingly, the Secretary of Energy has concluded that TSL 3 offers the maximum improvement in efficiency that is technologically feasible and economically justified, and would result in the significant conservation of energy.

Therefore, based on the above considerations, DOE is adopting the AFUE energy conservation standards for residential boilers at TSL 3. The amended energy conservation standards for residential boilers, which are expressed as AFUE, are shown in Table V.53.

TABLE V.53—AMENDED AFUE ENERGY CONSERVATION STANDARDS FOR RESIDENTIAL BOILERS

Product class	Standard: AFUE (%)	Design requirement
Gas-fired hot water boiler	84	Constant-burning pilot not permitted. Automatic means for adjusting water temperature required (except for boilers equipped with tankless domestic water heating coils).
Gas-fired steam boiler	82	Constant-burning pilot not permitted.
Oil-fired hot water boiler	86	Automatic means for adjusting temperature required (except for boilers equipped with tankless domestic water heating coils).
Oil-fired steam boiler	85	None.
Electric hot water boiler	None	Automatic means for adjusting temperature required (except for boilers equipped with tankless domestic water heating coils).
Electric steam boiler	None	None.

2. Benefits and Burdens of Trial Standard Levels Considered for Residential Boilers for Standby Mode and Off Mode

Table V.54 and Table V.55 summarize the quantitative impacts estimated for each TSL considered for residential boiler standby mode and off mode power standards. The national impacts are measured over the lifetime of residential boilers purchased in the 30-year period that begins in the year of anticipated compliance with new standards (2021–2050). The energy savings, emissions reductions, and value of emissions reductions refer to full-fuel-cycle results. The efficiency levels contained in each TSL are described in section V.A of this notice.

TABLE V.54—SUMMARY OF ANALYTICAL RESULTS FOR RESIDENTIAL BOILER STANDBY MODE AND OFF MODE TSLS: NATIONAL IMPACTS

Category	Trial Standard Level		
	1	2	3
Cumulative FFC Energy Savings (quads)	0.0009	0.0013	0.0026.
NPV of Consumer Costs and Benefits (2014$ billion)			
3% discount rate	0.007	0.004	0.014.
7% discount rate	0.002	(0.00005)	0.003.
Cumulative FFC Emissions Reduction			
CO_2 (*million metric tons*)	0.055	0.076	0.153.
SO_2 (*thousand tons*)	0.031	0.043	0.087.
NO_X (*thousand tons*)	0.099	0.139	0.278.
Hg (*lbs*)	0.229	0.321	0.642.
CH_4 (*thousand tons*)	0.239	0.334	0.669.
CH_4 (*thousand tons* CO_2eq) *	6.69	9.36	18.7.
N_2O (*thousand tons*)	0.001	0.001	0.002.

TABLE V.54—SUMMARY OF ANALYTICAL RESULTS FOR RESIDENTIAL BOILER STANDBY MODE AND OFF MODE TSLs: NATIONAL IMPACTS—Continued

Category	Trial Standard Level		
	1	2	3
N_2O (*thousand tons* CO_2eq) *	0.172	0.240	0.481.
Value of Emissions Reduction (Cumulative FFC Emissions)			
CO_2 (2014$ million) **	0.303 to 4.62	0.424 to 6.47	0.848 to 12.9.
NO_X—3% discount rate (2014$ million)	0.255 to 0.561	0.357 to 0.786	0.713 to 1.571.
NO_X—7% discount rate (2014$ million)	0.082 to 0.184	0.115 to 0.258	0.231 to 0.516.

* 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.55—SUMMARY OF ANALYTICAL RESULTS FOR RESIDENTIAL BOILER STANDBY MODE AND OFF MODE TSLs: MANUFACTURER AND CONSUMER IMPACTS

Category	Trial Standard Level		
	1	2	3
Manufacturer Impacts			
Industry NPV (2014$ million) (Base Case INPV = 367.83	367.61 to 367.73	367.74 to 367.78	366.12 to 368.28.
Industry NPV (*$ change*)	(0.22) to (0.10)	(0.09) to (0.04)	(1.71) to 0.45.
Industry NPV (*% change*)	(0.06) to (0.03)	(0.02) to (0.01)	(0.46) to 0.12.
Consumer Average LCC Savings (2014$)			
Gas-fired Hot Water Boiler	26	2	15.
Gas-fired Steam Boiler	31	4	18.
Oil-fired Hot Water Boiler	32	6	20.
Oil-fired Steam Boiler	26	0.4	13.
Electric Hot Water Boiler	19	(3)	8.
Electric Steam Boiler	17	(5)	6.
Shipment-Weighted Average *	27	3	16.
Consumer Simple PBP (years)			
Gas-fired Hot Water Boiler	2.0	8.9	6.7.
Gas-fired Steam Boiler	1.9	8.5	6.4.
Oil-fired Hot Water Boiler	1.8	8.2	6.2.
Oil-fired Steam Boiler	1.8	8.0	6.1.
Electric Hot Water Boiler	2.6	11.7	8.9.
Electric Steam Boiler	2.6	11.7	8.8.
Shipment-Weighted Average *	2.0	8.8	6.7.
Percentage of Consumers that Experience a Net Cost			
Gas-fired Hot Water Boiler	0.0%	3.7%	1.8%.
Gas-fired Steam Boiler	0.0%	1.3%	0.5%.
Oil-fired Hot Water Boiler	0.0%	3.5%	1.4%.
Oil-fired Steam Boiler	0.0%	1.3%	0.6%.
Electric Hot Water Boiler	0.0%	1.5%	1.0%.
Electric Steam Boiler	0.0%	1.5%	1.0%.
Shipment-Weighted Average *	0.0%	3.3%	1.5%.

* Weighted by shares of each product class in total projected shipments in 2021.
Note: Parentheses indicate negative (−) values.

DOE first considered TSL 3, which represents the max-tech efficiency levels. TSL 3 would save an estimated 0.0026 quads of energy. Under TSL 3, the NPV of consumer benefit would be $0.003 billion using a discount rate of 7 percent, and $0.014 billion using a discount rate of 3 percent.

The cumulative emissions reductions at TSL 3 are 0.153 Mt of CO_2, 0.087 thousand tons of SO_2, 0.278 thousand tons of NO_X, 0.642 lbs of Hg, 0.669 thousand tons of CH_4, and 0.002 thousand tons of N_2O. The estimated monetary value of the CO_2 emissions reduction at TSL 3 ranges from $0.848 million to $12.9 million.

At TSL 3, the average LCC impact is a savings of $15 for gas-fired hot water boilers, $18 for gas-fired steam boilers, $20 for oil-fired hot water boilers, $13 for oil-fired steam boilers, $8 for electric hot water boilers, and $6 for electric steam boilers. The simple payback period is 6.7 years for gas-fired hot water boilers, 6.4 years for gas-fired steam boilers, 6.2 years for oil-fired hot water boilers, 6.1 years for oil-fired steam boilers, 8.9 for electric hot water boilers, and 8.8 for electric steam boilers. The share of consumers experiencing a net LCC cost is 1.8 percent for gas-fired hot water boilers, 0.5 percent for gas-fired steam boilers, 1.4 percent for oil-fired hot water boilers, and 0.6 percent for oil-fired steam boilers, 1.0 percent for electric hot water boilers, and 1.0 percent for electric steam boilers.

At TSL 3, the projected change in INPV ranges from a decrease of $1.71 million to an increase of $0.45 million, depending on the manufacturer markup scenario. If the larger decrease is realized, TSL 3 could result in a net loss of 0.46 percent in INPV to manufacturers of covered residential boilers.

Accordingly, the Secretary concludes that at TSL 3 for residential boiler standby mode and off mode power, the benefits of energy savings, positive NPV of consumer benefits at both 7-percent and 3-percent discount rates, emission reductions, the estimated monetary value of the emissions reductions, and positive average LCC savings would outweigh the negative impacts on some consumers and on manufacturers, including the conversion costs that could result in a reduction in INPV for manufacturers. Accordingly, the Secretary has concluded that TSL 3 would offer the maximum improvement in efficiency that is technologically feasible and economically justified, and would result in the significant conservation of energy.

Therefore, based on the above considerations, DOE is adopting the standby mode and off mode energy conservation standards for residential boilers at TSL 3. The new energy conservation standards for standby mode and off mode, which are expressed as maximum power in watts, are shown in Table V.56.

TABLE V.56—STANDBY MODE AND OFF MODE ENERGY CONSERVATION STANDARDS FOR RESIDENTIAL BOILERS

Product class	$P_{W,SB}$ (watts)	$P_{W,OFF}$ (watts)
Gas-fired hot water boiler	9	9
Gas-fired steam boiler	8	8
Oil-fired hot water boiler	11	11
Oil-fired steam boiler	11	11
Electric hot water boiler	8	8
Electric steam boiler	8	8

3. Annualized Benefits and Costs of the Adopted Standards

The benefits and costs of the adopted standards can also be expressed in terms of annualized values. The annualized monetary value of net benefits is the sum of: (1) The annualized national economic value (expressed in 2014$) of the benefits from operating products that meet the adopted standards (consisting primarily of operating cost savings from using less energy, minus increases in product purchase costs), which is another way of representing consumer NPV, and (2) the annualized monetary value of the benefits of CO_2 and NO_X emission reductions.[128]

Table V.57 shows the annualized benefit and cost values for residential boilers under TSL 3 for AFUE standards, 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/t in 2015),[129] the estimated cost of the AFUE standards in this rule is $17.0 million per year in increased equipment costs, while the estimated benefits are $56.5 million per year in reduced equipment operating costs, $15.5 million per year in CO_2 reductions, and $12.3 million per year in reduced NO_X emissions. In this case, the net benefit amounts to $67.4 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/t in 2015, the estimated cost of the AFUE standards is $15.9 million per year in increased equipment costs, while the estimated benefits are $86.8 million per year in reduced operating costs, $15.5 million per year in CO_2 reductions, and $19.4 million per year in reduced NO_X emissions. In this case, the net benefit amounts to $105.8.

TABLE V.57—ANNUALIZED BENEFITS AND COSTS OF ADOPTED AFUE STANDARDS (TSL 3) FOR RESIDENTIAL BOILERS *

	Million 2014$/year			
	Discount rate (%)	Primary estimate *	Low-net-benefits estimate *	High-net-benefits estimate *
Benefits				
Consumer Operating Cost Savings	7	56.5	53.5	60.1.
	3	86.8	81.6	92.8.
CO_2 Reduction Monetized Value ($12.2/t case) **	5	4.4	4.3	4.5.
CO_2 Reduction Monetized Value ($40.0/t case) **	3	15.5	15.3	15.8.
CO_2 Reduction Monetized Value ($62.3/t case) **	2.5	23.0	22.7	23.4.
CO_2 Reduction Monetized Value ($117/t case) **	3	47.5	46.8	48.3.

[128] To convert the time-series of costs and benefits into annualized values, DOE calculated a present value in 2014, 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 (2021, 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.

[129] DOE used a 3-percent discount rate because the SCC values for the series used in the calculation were derived using a 3-percent discount rate (see section IV.L).

TABLE V.57—ANNUALIZED BENEFITS AND COSTS OF ADOPTED AFUE STANDARDS (TSL 3) FOR RESIDENTIAL BOILERS *—Continued

	Million 2014$/year			
	Discount rate (%)	Primary estimate *	Low-net-benefits estimate *	High-net-benefits estimate *
NO_X Reduction Monetized Value †	7 3	12.3 19.4	12.2 19.2	28.0 43.2.
Total Benefits††	7 plus CO_2 range 7 3 plus CO_2 range 3	73 to 116 84.4 111 to 154 121.7	70 to 112 81.0 105 to 148 116.1	93 to 136. 104.0. 141 to 184. 151.9.
Costs				
Consumer Incremental Installed Costs	7 3	17.0 15.9	19.9 19.2	14.7 13.4.
Net benefits/costs				
Total ††	7 plus CO_2 range 7 3 plus CO_2 range 3	56 to 99 67.4 95 to 138 105.8	50 to 93 61.1 86 to 128 96.9	78 to 122. 89.3. 127 to 171. 138.5.

* This table presents the annualized costs and benefits associated with residential boilers shipped in 2021–2050. These results include benefits to consumers which accrue after 2050 from the products purchased in 2021–2050. The Primary, Low Benefits, and High Benefits Estimates utilize projections of energy prices from the *AEO 2015* Reference case, Low Economic Growth case, and High Economic Growth case, respectively. In addition, incremental product costs reflect a medium decline rate in the Primary Estimate, a low decline rate in the Low Benefits Estimate, and a high decline rate in the High Benefits Estimate. The methods used to derive projected price trends are explained in section IV.F.1.

** The CO_2 values represent global monetized values of the SCC, in 2014$, in 2015 under several scenarios of the updated SCC values. The first three cases use the averages of the SCC distributions calculated using 5%, 3%, and 2.5% discount rates, respectively. The fourth case represents the 95th percentile of the SCC distribution calculated using a 3% discount rate. The SCC time series incorporate an escalation factor.

† 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: *http://www3.epa.gov/ttnecas1/regdata/RIAs/111dproposalRIAfinal0602.pdf.*) For DOE's Primary Estimate and Low Net Benefits Estimate, 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). For DOE's High Net Benefits Estimate, the benefit-per-ton estimates were based on the Six Cities study (Lepuele et al., 2011), which are nearly two-and-a-half times larger than those from the ACS study. Because of the sensitivity of the benefit-per-ton estimate to the geographical considerations of sources and receptors of emission, 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% and 7% cases are derived using the series corresponding to the average SCC with the 3-percent discount rate ($40.0/t in 2015) case. 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.

Table V.58 shows the annualized benefit and cost values for residential boilers under TSL 3 for standby mode and off mode standards, 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/t in 2015), the estimated cost of the residential boiler standby mode and off mode standards in this rule is $0.46 million per year in increased equipment costs, while the estimated benefits are $0.84 million per year in reduced equipment operating costs, $0.25 million per year in CO_2 reductions, and $0.03 million per year in reduced NO_X emissions. In this case, the net benefit amounts to $0.66 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/t in 2015, the estimated cost of the AFUE standards is $0.46 million per year in increased equipment costs, while the estimated benefits are $1.28 million per year in reduced operating costs, $0.25 million per year in CO_2 reductions, and $0.04 million per year in reduced NO_X emissions. In this case, the net benefit amounts to $1.11 million per year.

TABLE V.58—ANNUALIZED BENEFITS AND COSTS OF ADOPTED STANDBY MODE AND OFF MODE STANDARDS (TSL 3) FOR RESIDENTIAL BOILERS *

	Million 2014$/year			
	Discount rate (%)	Primary estimate *	Low-net-benefits estimate *	High-net-benefits estimate *
Benefits				
Consumer Operating Cost Savings	7 3	0.84 1.28	0.81 1.25	0.89. 1.38.
CO_2 Reduction Monetized Value ($12.2/t case) **	5	0.07	0.07	0.07.

TABLE V.58—ANNUALIZED BENEFITS AND COSTS OF ADOPTED STANDBY MODE AND OFF MODE STANDARDS (TSL 3) FOR RESIDENTIAL BOILERS *—Continued

	Million 2014$/year			
	Discount rate (%)	Primary estimate *	Low-net-benefits estimate *	High-net-benefits estimate *
CO_2 Reduction Monetized Value ($40.0/t case) **	3	0.25	0.25	0.26.
CO_2 Reduction Monetized Value ($62.3/t case) **	2.5	0.37	0.36	0.38.
CO_2 Reduction Monetized Value ($117/t case) **	3	0.77	0.75	0.79.
NO_X Reduction Monetized Value †	7	0.03	0.03	0.06.
	3	0.04	0.04	0.10.
Total Benefits ††	7 plus CO_2 range	0.94 to 1.63	0.91 to 1.59	1.02 to 1.74.
	7	1.12	1.09	1.21.
	3 plus CO_2 range	1.40 to 2.09	1.36 to 2.04	1.54 to 2.26.
	3	1.58	1.54	1.73.
Costs				
Consumer Incremental Installed Costs	7	0.46	0.45	0.47.
	3	0.46	0.45	0.47.
Net benefits/costs				
Total ††	7 plus CO_2 range	0.48 to 1.17	0.46 to 1.14	0.55 to 1.26.
	7	0.66	0.63	0.73.
	3 plus CO_2 range	0.93 to 1.63	0.91 to 1.59	1.07 to 1.78.
	3	1.11	1.09	1.25.

* This table presents the annualized costs and benefits associated with residential boilers shipped in 2021–2050. These results include benefits to consumers which accrue after 2050 from the products purchased in 2021–2050. The Primary, Low Benefits, and High Benefits Estimates utilize projections of energy prices from the *AEO 2015* Reference case, Low Economic Growth case, and High Economic Growth case, respectively.

** The CO_2 values represent global monetized values of the SCC, in 2014$, in 2015 under several scenarios of the updated SCC values. The first three cases use the averages of the SCC distributions calculated using 5%, 3%, and 2.5% discount rates, respectively. The fourth case represents the 95th percentile of the SCC distribution calculated using a 3% discount rate. The SCC time series incorporate an escalation factor.

† 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: *http://www3.epa.gov/ttnecas1/regdata/RIAs/111dproposalRIAfinal0602.pdf.*) For DOE's Primary Estimate and Low Net Benefits Estimate, 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). For DOE's High Net Benefits Estimate, the benefit-per-ton estimates were based on the Six Cities study (Lepuele et al., 2011), which are nearly two-and-a-half times larger than those from the ACS study. Because of the sensitivity of the benefit-per-ton estimate to the geographical considerations of sources and receptors of emission, 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% and 7% cases are derived using the series corresponding to the average SCC with the 3-percent discount rate ($40.0/t in 2015) case. 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.

In order to provide a complete picture of the overall impacts of this final rule, the following combines and summarizes the benefits and costs for both the amended AFUE standards and the new standby mode and off mode standards for residential boilers. Table V.59 shows the combined annualized benefit and cost values for the AFUE standards and the standby mode and off mode standards for residential boilers. 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/t in 2015), the estimated cost of the residential boiler AFUE, standby mode, and off mode standards in this rule is $17.4 million per year in increased equipment costs, while the estimated benefits are $57.4 million per year in reduced equipment operating costs, $15.8 million per year in CO_2 reductions, and $12.4 million per year in reduced NO_X emissions. In this case, the net benefit amounts to $68.1 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/t in 2015, the estimated cost of the residential boiler AFUE, standby mode, and off mode standards in this rule is $16.4 million per year in increased equipment costs, while the estimated benefits are $88.1 million per year in reduced equipment operating costs, $15.8 million per year in CO_2 reductions, and $19.4 million per year in reduced NO_X emissions. In this case, the net benefit amounts to $106.9 million per year.

TABLE V.59—ANNUALIZED BENEFITS AND COSTS OF ADOPTED AFUE AND STANDBY MODE AND OFF MODE ENERGY CONSERVATION STANDARDS (TSL 3) FOR RESIDENTIAL BOILERS *

	Discount rate (%)	Million 2014$/year		
		Primary estimate *	Low-net-benefits estimate *	High-net-benefits estimate *
Benefits				
Consumer Operating Cost Savings.	7	57.4	54.3	61.0.
	3	88.1	82.8	94.2.
CO_2 Reduction Value ($12.2/t case) **.	5	4.5	4.4	4.6.
CO_2 Reduction Value ($40.0/t case) **.	3	15.8	15.6	16.1.
CO_2 Reduction Value ($62.3/t case) **.	2.5	23.4	23.0	23.8.
CO_2 Reduction Value ($117/t case) **.	3	48.2	47.5	49.1.
NO_X Reduction Value †	7	12.4	12.2	28.0.
	3	19.4	19.2	43.3.
Total Benefits ††	7 plus CO_2 range	74.2 to 117.9	70.9 to 114	93.6 to 138.
	7	85.5	82.1	105.
	3 plus CO_2 range	112 to 156	106 to 150	142 to 187.
	3	123.3	117.6	153.6.
Costs				
Consumer Incremental Installed Costs.	7	17.4	20.3	15.1.
	3	16.4	19.6	13.9.
Net Benefits/Costs				
Total ††	7 plus CO_2 range	56.8 to 100	50.6 to 93.7	78.5 to 123.
	7	68.1	61.8	90.0.
	3 plus CO_2 range	95.6 to 139	86.8 to 130	128 to 173.
	3	106.9	98.0	139.7.

* This table presents the annualized costs and benefits associated with residential boilers shipped in 2021–2050. These results include benefits to consumers which accrue after 2050 from the products purchased in 2021–2050. The Primary, Low Benefits, and High Benefits Estimates utilize projections of energy prices from the *AEO 2015* Reference case, Low Economic Growth case, and High Economic Growth case, respectively. In addition, incremental product costs reflect a medium decline rate in the Primary Estimate, a low decline rate in the Low Benefits Estimate, and a high decline rate in the High Benefits Estimate. The methods used to derive projected price trends are explained in section IV.F.1.

** The CO_2 values represent global monetized values of the SCC, in 2014$, in 2015 under several scenarios of the updated SCC values. The first three cases use the averages of the SCC distributions calculated using 5%, 3%, and 2.5% discount rates, respectively. The fourth case represents the 95th percentile of the SCC distribution calculated using a 3% discount rate. The SCC time series incorporate an escalation factor.

† 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: *http://www3.epa.gov/ttnecas1/regdata/RIAs/111dproposalRIAfinal0602.pdf.*) For DOE's Primary Estimate and Low Net Benefits Estimate, 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). For DOE's High Net Benefits Estimate, the benefit-per-ton estimates were based on the Six Cities study (Lepuele et al., 2011), which are nearly two-and-a-half times larger than those from the ACS study. Because of the sensitivity of the benefit-per-ton estimate to the geographical considerations of sources and receptors of emission, 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% and 7% cases are derived using the series corresponding to the average SCC with the 3-percent discount rate ($40.0/t in 2015) case. 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 the adopted standards for residential boilers are intended to address are as follows:

(1) Insufficient information and the high costs of gathering and analyzing relevant information lead some consumers to miss opportunities to make cost-effective investments in energy efficiency.

(2) In some cases, the benefits of more-efficient equipment are not realized due to misaligned incentives between purchasers and users. An example of such a case is when the equipment purchase decision is made by a building contractor or building owner who does not pay the energy costs of operating the equipment.

(3) There are external benefits resulting from improved energy efficiency of appliances that are not captured by the users of such equipment. These benefits include externalities related to public health, environmental protection, and national energy security that are not reflected in energy prices, such as reduced emissions of air pollutants and greenhouse gases that impact human health and global warming. DOE attempts to qualify 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 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, OIRA has emphasized that such techniques may include identifying changing future compliance costs that might result from technological innovation or anticipated behavioral changes. For the reasons stated in the preamble, DOE believes that this final rule 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 a final regulatory flexibility analysis (FRFA) for any final rule unless the agency certifies that the rule 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 FRFA for the products that are the subject of this rulemaking.

For manufacturers of residential boilers, the Small Business Administration (SBA) has set a size threshold, which defines those entities classified as ''small businesses'' for the purposes of the statute. DOE used the SBA's small business size standards to determine whether any small entities would be subject to the requirements of the rule. See 13 CFR part 121. The size standards are listed by North American Industry Classification System (NAICS) code and industry description and are available at *http://www.sba.gov/category/navigation-structure/contracting/contracting-officials/small-business-size-standards.* Manufacturing of residential boilers is classified under NAICS 333414, ''Heating Equipment (except Warm Air Furnaces) Manufacturing.'' The SBA sets a threshold of 500 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 products covered by this rulemaking, DOE conducted a market survey using publically-available information to identify potential small manufacturers. DOE's research involved industry trade association membership directories (including AHRI), public databases (*e.g.,* AHRI Directory,[130] the California Energy Commission Appliance Efficiency Database[131]), individual company Web sites, and market research tools (*e.g.,* Hoovers reports[132]) to create a list of companies that manufacture or sell products covered by this rulemaking. DOE also asked stakeholders and industry representatives if they were aware of any other small manufacturers during manufacturer interviews and at DOE public meetings. 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 residential boilers. DOE screened out companies that do not offer products covered by this rulemaking, do not meet the definition of a ''small business,'' or are foreign owned and operated.

DOE identified 36 manufacturers of residential boilers sold in the U.S. DOE then determined that 23 are large manufacturers or manufacturers that are foreign owned and operated. The remaining 13 domestic manufacturers meet the SBA's definition of a ''small business.'' Of these 13 small businesses, nine manufacture the boilers covered by this rulemaking, while the other four manufacturers rebrand imported

[130] See *www.ahridirectory.org/ahriDirectory/pages/home.aspx.*

[131] See *http://www.energy.ca.gov/appliances/.*

[132] See *http://www.hoovers.com.*

products or products manufactured by other small companies.

Before issuing this final rule, DOE attempted to contact all the small business manufacturers of residential boilers 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 15 percent of the residential boiler market. Based on DOE's research, three small businesses manufacture all four product classes of boilers domestically; four small businesses primarily produce condensing boiler products (and rely heat exchangers sourced from other manufacturers); and two manufacturers primarily produce oil-fired hot water boiler products. The remaining four small businesses wholesale or rebrand products that are imported from Europe or Asia, or design products and source manufacturing to a domestic firm.

2. Description and Estimate of Compliance Requirements

When confronted with new or amended energy conservation standards, small businesses must make investments in research and development to redesign their products, but because they have lower sales volumes, they must spread these costs across fewer units. Moreover, smaller manufacturers may experience higher per-model testing costs relative to larger manufacturers, as they may not possess their own test facilities and, therefore, must outsource all testing at a higher per-unit cost.

These considerations could affect the three small manufacturers that offer all four product classes, the two manufacturers that only produce one or two product classes, and the four small businesses that rebrand boilers that do their own design work could see negative impacts. Being small businesses, it is likely that these manufacturers have fewer engineers and product development resources and may have greater difficulty bringing their portfolio of products into compliance with the new and amended energy conservation standards within the allotted timeframe. Also, these small manufacturers may have to divert engineering resources from customer and new product initiatives for a longer period of time.

Smaller manufacturers often lack the purchasing power of larger manufacturers. For example, suppliers of bulk purchase parts and components (such as gas valves) give boiler manufacturers discounts based on the quantities purchased. Therefore, larger manufacturers may have a pricing advantage because they have higher volume purchases. This purchasing power differential between high-volume and low-volume orders applies to other residential boiler components as well, such as ignition systems and inducer fan assemblies.

To meet the new and amended standards, manufacturers may have to seek outside capital to cover expenses related to testing and product design equipment. Smaller firms typically have a higher cost of borrowing due to higher perceived risk on the part of investors, largely attributed to lower cash flows and lower per-unit profitability. In these cases, small manufacturers may observe higher costs of debt than larger manufacturers.

While DOE does not expect high capital conversion costs at TSL 3, DOE does expect smaller businesses would have to make significant product conversion investments relative to larger manufacturers. As previously noted, some of these smaller manufacturers are heavily weighted toward baseline products and other products below the efficiency levels adopted in this notice. As Table VI.1 illustrates, smaller manufacturers would have to increase their R&D spending to bring products into compliance and to develop new products at TSL 3, the adopted level.

TABLE VI.1—IMPACTS OF CONVERSION COSTS ON A SMALL MANUFACTURER

	Capital conversion cost as a percentage of annual capital expenditures	Product conversion cost as a percentage of annual R&D expense	Total conversion cost as a percentage of annual revenue	Total conversion cost as a percentage of annual EBIT *
Average Large Manufacturer	3	10	0	3
Average Small Manufacturer	17	79	2	22

* EBIT means "earnings before interest and taxes."

At TSL 3, the level adopted in this notice, DOE estimates capital conversion costs of $0.01 million and product conversion costs of $0.05 million for an average small manufacturer. DOE estimates that an average large manufacturer will incur capital conversion costs of $0.02 million and product conversion costs of $0.05 million. Based on the results in Table VI.1, DOE recognizes that small manufacturers will generally face a relatively higher conversion cost burden than larger competitors.

Manufacturers that have the majority of their products and sales at efficiency levels above the adopted standards may have lower conversion costs than those listed in Table VI.1. In particular, the four small manufacturers that primarily sell condensing products are unlikely to be affected by the efficiency levels at TSL 3, as all of their products are already above the efficiency levels being adopted.

Furthermore, DOE recognizes that small manufacturers that primarily sell low-efficiency products today will face a greater burden relative to the small manufacturers that primarily sell high-efficiency products. At TSL 3, the level adopted in this notice, DOE believes that the three manufacturers that manufacture across all four product classes would have higher conversion costs because many of their products do not meet the standard adopted in this notice and would require redesign. Consequently, these manufacturers would have to expend funds to redesign their commodity products, or develop a new, higher-efficiency baseline product.

The two companies that primarily produce oil-fired hot water boilers could also be impacted, as they are generally much smaller than the small businesses that produce all product classes, have fewer shipments and smaller revenues, and are likely to have limited R&D resources. Both of these companies, however, do have oil-fired hot water boiler product listings that meet the efficiency standards adopted in this notice.

DOE estimates that one of the four companies that rebrands imported or sourced products does its own design work, while the other three import high-efficiency products from Europe or Asia. It is possible that the company that designs its own products could be affected by product conversion costs at TSL 3, while it is unlikely that the other three would be greatly impacted.

Based on this analysis, DOE notes that on average, small businesses will experience total conversion costs on the order of $60,000. However, some companies will fall below and above the average. In particular, DOE has identified two small manufacturers that could experience greater conversion costs burdens than indicated by the average due to not having any products meeting the standard in one or two product classes.

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 final rule being adopted.

4. Significant Alternatives to the Rule

The discussion in the previous section analyzes impacts on small businesses that would result from DOE's final rule, represented by TSL 3. In reviewing alternatives to the final rule, DOE examined energy conservation standards set at lower efficiency levels. While TSL 1 and TSL 2 would reduce the impacts on small business manufacturers, it would come at the expense of a reduction in energy savings. TSL 1 for the AFUE standards achieves 57 percent lower energy savings compared to the energy savings at TSL 3. TSL 2 for the AFUE standards achieves 36 percent lower energy savings compared to the energy savings at TSL 3.

DOE believes that establishing standards at TSL 3 balances the benefits of the energy savings at TSL 3 with the potential burdens placed on residential boiler manufacturers, including small business manufacturers. Accordingly, DOE is not adopting one of the other TSLs considered in the analysis, or the other policy alternatives examined as part of the regulatory impacts analysis and included in chapter 17 of the NOPR TSD.

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 million may apply for an exemption from all or part of an energy conservation standard for a period not longer than 24 months after the effective date of a final rule establishing the standard. 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 residential boilers must certify to DOE that their products comply with any applicable energy conservation standards. In certifying compliance, manufacturers must test their products according to the DOE test procedure for residential boilers, including any amendments adopted for those test procedures. DOE has established regulations for the certification and recordkeeping requirements for all covered consumer products and commercial equipment, including residential boilers. 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 this 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 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 rule. DOE's CX determination for this 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 (Aug. 10, 1999), imposes certain requirements on Federal agencies formulating and implementing policies or regulations that preempt State law or that have Federalism implications. The Executive Order requires agencies to examine the constitutional and statutory authority supporting any action that would limit the policymaking discretion of the States and to carefully assess the necessity for such actions. The Executive Order also requires agencies to have an accountable process to ensure meaningful and timely input by State and local officials in the development of regulatory policies that have Federalism implications. On March 14, 2000, DOE published a statement of policy describing the intergovernmental consultation process it will follow in the development of such regulations. 65 FR 13735. DOE has examined this rule and has determined that it would not have a substantial direct effect on the States, on the relationship between the national government and the States, or on the distribution of power and responsibilities among the various levels of government. EPCA governs and prescribes Federal preemption of State regulations as to energy conservation for the products that are the subject of this final rule. States can petition DOE for exemption from such preemption to the extent, and based on criteria, set forth in EPCA. (42 U.S.C. 6297) Therefore, no further action is required by Executive Order 13132.

F. Review Under Executive Order 12988

With respect to the review of existing regulations and the promulgation of new regulations, section 3(a) of Executive Order 12988, "Civil Justice Reform," imposes on Federal agencies the general duty to adhere to the following requirements: (1) Eliminate drafting errors and ambiguity; (2) write regulations to minimize litigation; (3) provide a clear legal standard for affected conduct rather than a general standard; and (4) promote simplification and burden reduction. 61 FR 4729 (Feb. 7, 1996). Regarding the review required by section 3(a), section 3(b) of Executive

Order 12988 specifically requires that Executive agencies make every reasonable effort to ensure that the regulation: (1) Clearly specifies the preemptive effect, if any; (2) clearly specifies any effect on existing Federal law or regulation; (3) provides a clear legal standard for affected conduct while promoting simplification and burden reduction; (4) specifies the retroactive effect, if any; (5) adequately defines key terms; and (6) addresses other important issues affecting clarity and general draftsmanship under any guidelines issued by the Attorney General. Section 3(c) of Executive Order 12988 requires Executive agencies to review regulations in light of applicable standards in section 3(a) and section 3(b) to determine whether they are met or it is unreasonable to meet one or more of them. DOE has completed the required review and determined that, to the extent permitted by law, this final 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 regulatory action likely to result in a rule that may cause the expenditure by State, local, and Tribal governments, in the aggregate, or by the private sector of $100 million or more in any one year (adjusted annually for inflation), section 202 of UMRA requires a Federal agency to publish a written statement that estimates the resulting costs, benefits, and other effects on the national economy. (2 U.S.C. 1532(a), (b)) The UMRA also requires a Federal agency to develop an effective process to permit timely input by elected officers of State, local, and Tribal governments on a ''significant intergovernmental mandate,'' and requires an agency plan for giving notice and opportunity for timely input to potentially affected small governments before establishing any requirements that might significantly or uniquely affect them. On March 18, 1997, DOE published a statement of policy on its process for intergovernmental consultation under UMRA. 62 FR 12820. DOE's policy statement is also available at *http://energy.gov/sites/prod/files/gcprod/documents/umra_97.pdf.*

Although it does not contain a Federal intergovernmental mandate, DOE has concluded that this final rule adopting amended and new energy conservation standards for residential boilers may require annual expenditures of $100 million or more in any one year by the private sector. Such expenditures may include: (1) Investment in research and development and in capital expenditures by residential boiler manufacturers in the years between the final rule and the compliance date for the new standards, and (2) incremental additional expenditures by consumers to purchase higher-efficiency residential boilers, starting at the compliance date for the applicable standard.

Section 202 of UMRA authorizes a Federal agency to respond to the content requirements of UMRA in any other statement or analysis that accompanies the final rule. (2 U.S.C. 1532(c)) The content requirements of section 202(b) of UMRA relevant to a private sector mandate substantially overlap the economic analysis requirements that apply under section 325(o) of EPCA and Executive Order 12866. The **SUPPLEMENTARY INFORMATION** section of this document and the ''Regulatory Impact Analysis'' section of the TSD for this final 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 rule unless DOE publishes an explanation for doing otherwise, or the selection of such an alternative is inconsistent with law. As required by 42 U.S.C. 6295(f) and (o), this final rule establishes amended and new energy conservation standards for residential boilers 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 (chapter 17) for this final rule.

H. Review Under the Treasury and General Government Appropriations Act, 1999

Section 654 of the Treasury and General Government Appropriations Act, 1999 (Pub. L. 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 18, 1988), DOE has determined that this rule would not result in any takings that might require compensation under the Fifth Amendment to the U.S. Constitution.

J. Review Under the Treasury and General Government Appropriations Act, 2001

Section 515 of the Treasury and General Government Appropriations Act, 2001 (44 U.S.C. 3516 note) provides for Federal agencies to review most disseminations of information to the public under information quality guidelines established by each agency pursuant to general guidelines issued by OMB. OMB's guidelines were published at 67 FR 8452 (Feb. 22, 2002), and DOE's guidelines were published at 67 FR 62446 (Oct. 7, 2002). DOE has reviewed this final rule under the OMB and DOE guidelines and has concluded that it is consistent with applicable policies in those guidelines.

K. Review Under Executive Order 13211

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 significant energy action. A ''significant energy action'' is defined as any action by an agency that promulgates or is expected to lead to promulgation of a final rule, and that: (1) Is a significant regulatory action under Executive Order 12866, or any successor order; and (2) is likely to have a significant adverse effect on the supply, distribution, or use of energy, or (3) is designated by the Administrator of OIRA as a significant energy action. For any significant energy action, the agency must give a detailed statement of any adverse effects on energy supply, distribution, or use should the proposal be implemented, and of reasonable alternatives to the action and their expected benefits on energy supply, distribution, and use.

DOE has concluded that this regulatory action, which sets forth amended and new energy conservation standards for residential boilers, is not a significant energy action because the standards are not likely to have a significant adverse effect on the supply, distribution, or use of energy, nor has it been designated as such by the Administrator at OIRA. Accordingly, DOE has not prepared a Statement of Energy Effects on this final rule.

L. 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 FR 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.*

M. Congressional Notification

As required by 5 U.S.C. 801, DOE will report to Congress on the promulgation of this rule prior to its effective date. The report will state that it has been determined that the rule is a ''major rule'' as defined by 5 U.S.C. 804(2).

VII. Approval of the Office of the Secretary

The Secretary of Energy has approved publication of this final rule.

List of Subjects in 10 CFR Part 430

Administrative practice and procedure, Confidential business information, Energy conservation, Household appliances, Imports, Intergovernmental relations, Small businesses.

Issued in Washington, DC, on December 30, 2015.

David J. Friedman,

Principal Deputy Assistant Secretary, Energy Efficiency and Renewable Energy.

For the reasons set forth in the preamble, DOE amends part 430 of chapter II, subchapter D, of title 10 of the Code of Federal Regulations, as set forth below:

PART 430—ENERGY CONSERVATION PROGRAM FOR CONSUMER PRODUCTS

■ 1. The authority citation for part 430 continues to read as follows:

Authority: 42 U.S.C. 6291–6309; 28 U.S.C. 2461 note.

■ 2. Section 430.32 is amended by:

■ a. Adding in paragraph (e)(2)(ii) introductory text, the words ''and before January 15, 2021,'' after ''2012,'';

■ b. Redesignating paragraphs (e)(2)(iii) and (iv) as paragraphs (e)(2)(iv) and (v), respectively; and

■ c. Adding new paragraph (e)(2)(iii).

The addition reads as follows:

§ 430.32 Energy and water conservation standards and their compliance dates.

* * * * *

(e) * * *

(2) * * *

(iii)(A) Except as provided in paragraph (e)(2)(v) of this section, the AFUE of residential boilers, manufactured on and after January 15, 2021, shall not be less than the following and must comply with the design requirements as follows:

Product class	AFUE [1] (percent)	Design requirements
(*1*) Gas-fired hot water boiler	84	Constant-burning pilot not permitted. Automatic means for adjusting water temperature required (except for boilers equipped with tankless domestic water heating coils).
(*2*) Gas-fired steam boiler	82	Constant-burning pilot not permitted.
(*3*) Oil-fired hot water boiler	86	Automatic means for adjusting temperature required (except for boilers equipped with tankless domestic water heating coils).
(*4*) Oil-fired steam boiler	85	None.
(*5*) Electric hot water boiler	None	Automatic means for adjusting temperature required (except for boilers equipped with tankless domestic water heating coils).
(*6*) Electric steam boiler	None	None.

[1] Annual Fuel Utilization Efficiency, as determined in § 430.23(n)(2) of this part.

(B) Except as provided in paragraph (e)(2)(v) of this section, the standby mode power consumption ($P_{W,SB}$) and off mode power consumption ($P_{W,OFF}$) of residential boilers, manufactured on and after January 15, 2021, shall not be more than the following:

Product class	$P_{W,SB}$ (watts)	$P_{W,OFF}$ (watts)
(*1*) Gas-fired hot water boiler	9	9
(*2*) Gas-fired steam boiler	8	8
(*3*) Oil-fired hot water boiler	11	11
(*4*) Oil-fired steam boiler	11	11
(*5*) Electric hot water boiler	8	8

Product class	$P_{W,SB}$ (watts)	$P_{W,OFF}$ (watts)
(*6*) Electric steam boiler	8	8

* * * * *

Note: The following letter will not appear in the Code of Federal Regulations.

U.S. Department of Justice
Antitrust Division
William J. Baer
Assistant Attorney General
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Washington, DC 20530–0001
(202)514–2401/(202)616–2645 (Fax)

July 1, 2015

Anne Harkavy
Deputy General Counsel for Litigation, Regulation and Enforcement
U.S. Department of Energy
1000 Independence Ave, SW.
Washington, DC 20585

Dear Deputy General Counsel Harkavy:

I am responding to your March 13, 2015 letters seeking the views of the Attorney General about the potential impact on competition of proposed energy conservation standards for residential boilers. Your request was submitted under Section 325(o)(2)(B)(i)(V) of the Energy Policy and Conservation Act, as amended (ECPA), 42 U.S.C. 6295(o)(2)(B)(i)(V), which requires the Attorney General to make a determination of the impact of any lessening of competition that is likely to result from the imposition of proposed energy conservation standards. The Attorney General's responsibility for responding to requests from other departments about the effect of a program on competition has been delegated to the Assistant Attorney General for the Antitrust Division in 28 CFR 0.40(g).

In conducting its analysis, the Antitrust Division examines whether a proposed standard may lessen competition, for example, by substantially limiting consumer choice or increasing industry concentration. A lessening of competition could result in higher prices to manufacturers and consumers.

We have reviewed the proposed energy conservation standards contained in the Notice of Proposed Rulemaking (80 FR 17222, March 31, 2015) (NOPR) and the related Technical Support Documents. We have also reviewed supplementary information submitted to the Attorney General by the Department of Energy, as well as material presented at the public meeting held on the proposed standards on April 30, 2015. Based on this review, our conclusion is that the proposed energy conservation standards for residential boilers are unlikely to have a significant adverse impact on competition.

Sincerely,

William J. Baer

[FR Doc. 2016–00025 Filed 1–14–16; 8:45 am]

BILLING CODE 6450–01–P