This document is scheduled to be published in the
Federal Register on 04/14/2015 and available online at
http://federalregister.gov/a/2015-07932, and on **FDsys.gov**

[6450-01-P]

DEPARTMENT OF ENERGY

10 CFR Parts 429, 430, and 431

[EERE-2015-BT-TP-0007]

RIN: 1904-AC91

Energy Conservation Program for Consumer Products and Certain Commercial and Industrial Equipment: Test Procedures for Consumer and Commercial Water Heaters

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

ACTION: Notice of proposed rulemaking.

SUMMARY: As required by the Energy Policy and Conservation Act of 1975 (EPCA), as amended, the U.S. Department of Energy (DOE) proposes to establish a mathematical conversion factor for the purpose of translating efficiency ratings for water heaters under the test method currently in effect to the ratings under the amended test method promulgated by DOE in a final rule published on July 11, 2014 (hereinafter referred to as the "the July 2014 final rule"). Compliance with the amended test procedure is required beginning on the later of: one year after the publication of a final rule that establishes a mathematical conversion factor, or December 31, 2015. This rulemaking document proposes a mathematical conversion factor which may be used to convert the existing efficiency ratings under the current Federal test procedure to efficiency ratings under the test procedure adopted in the July 2014 final rule for water heater basic models manufactured, tested and certified prior to the compliance date of the amended test procedure.

The amended test procedure applies to all covered consumer water heaters and the covered commercial water heating equipment with residential applications defined in the July 2014 final rule as a "residential-duty commercial water heater." In addition, this document proposes amendments to the minimum energy conservation standards for consumer water heaters and residential-duty commercial water heaters to account for the impact of the new metric, but does not alter the stringency of the existing energy conservation standards. While DOE has not planned a public meeting to discuss this proposal, DOE is willing to consider a request to hold a meeting.

DATES: Comments: DOE will accept comments, data, and information regarding this notice of proposed rulemaking (NOPR) no later than [**INSERT DATE 30 DAYS AFTER DATE OF PUBLICATION IN THE FEDERAL REGISTER**]. See section V, "Public Participation," for details.

ADDRESSES: All comments submitted must identify the NOPR for the Conversion Factor for Test Procedures for Consumer and Certain Commercial Water Heaters, and provide docket number EERE-2015-BT-TP-0007 and/or RIN 1904-AC91. Interested persons are encouraged to submit comments using the Federal eRulemaking Portal at www.regulations.gov. Follow the instructions for submitting comments. Alternatively, interested persons may submit comments by any of the following methods:

- E-mail: ConsumerCommWaterHtrs2015TP0007@ee.doe.gov. Include the docket number and/or RIN in the subject line of the message. Submit electronic comments in

WordPerfect, Microsoft Word, PDF, or ASCII file format, and avoid the use of special characters or any form of encryption.

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

- Hand Delivery/Courier: Ms. Brenda Edwards, U.S. Department of Energy, Building Technologies Office, 950 L'Enfant Plaza, SW., 6th Floor, Washington, DC, 20024. Telephone: (202) 586-2945. If possible, please submit all items on a CD, in which case it is not necessary to include printed copies.

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

Docket: The docket is available for review at www.regulations.gov, including Federal Register notices, comments, and other supporting documents/materials. 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-2015-BT-TP-0007. This webpage contains a link to the docket for this notice of proposed rulemaking on the www.regulations.gov site. The www.regulations.gov webpage contains simple instructions on how to access all documents, including public comments, in the docket. See section V, "Public Participation," for information on how to submit comments through www.regulations.gov.

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

FOR FURTHER INFORMATION CONTACT:

Ms. Ashley Armstrong, U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy, Building Technologies Office, EE-5B, 1000 Independence Avenue, SW., Washington, DC, 20585-0121. Telephone: (202) 586-6590. E-mail: Ashley.Armstrong@ee.doe.gov.

Mr. Eric Stas, U.S. Department of Energy, Office of the General Counsel, GC-33, 1000 Independence Avenue, SW., Washington, DC, 20585-0121. Telephone: (202) 586-9507. E-mail: Eric.Stas@hq.doe.gov.

SUPPLEMENTARY INFORMATION:

Table of Contents

I. Authority and Background
II. Summary of the Notice of Proposed Rulemaking
III. Discussion
A. Stakeholder Comments on Other Rulemakings
B. Scope
1. Test Procedure and Energy Conservation Standards Coverage
2. Units on the Market
C. Potential Approaches for Developing Conversions
1. Background Regarding Changes to Existing Test Procedures
2. Analytical Methods
3. Empirical Regression
D. Testing Conducted for the Mathematical Conversion
1. Consumer Water Heater Testing
2. Residential-Duty Commercial Water Heater Testing
E. Testing Results and Analysis of Test Data
1. Impact of Certain Water Heater Attributes on Efficiency Ratings
2. Conversion Factor Derivation
3. Energy Conservation Standard Derivation
F. Certification and Labeling Issues
IV. Procedural Issues and Regulatory Review
A. Review Under Executive Order 12866
B. Review Under the Regulatory Flexibility Act
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 Treasury and General Government Appropriations Act, 2001
K. Review Under Executive Order 13211
L. Review Under Section 32 of the Federal Energy Administration Act of 1974
V. Public Participation
A. Submission of Comments
B. Issues on Which DOE Seeks Comment
VI. Approval of the Office of the Secretary

I. Authority and Background

Title III Part B[1] of the Energy Policy and Conservation Act of 1975 ("EPCA" or, "the Act"), Pub. L. 94-163 (42 U.S.C. 6291–6309, as codified) sets forth a variety of provisions designed to improve energy efficiency and established the Energy Conservation Program for

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

Consumer Products Other Than Automobiles.[2] These include consumer water heaters, one subject of this document. (42 U.S.C. 6292(a)(4)) Title III, Part C[3] of EPCA, Pub. L. 94–163 (42 U.S.C. 6311–6317, as codified), added by Pub. L. 95–619, Title IV, Sec. 441(a), established the Energy Conservation Program for Certain Industrial Equipment, which includes the commercial water heating equipment that is another subject of this rulemaking. (42 U.S.C. 6311(1)(K))

Under EPCA, energy conservation programs generally consist of four parts: (1) testing; (2) labeling; (3) establishing Federal energy conservation standards; and (4) certification and enforcement procedures. The testing requirements consist of test procedures that manufacturers of covered products and equipment must use as the basis for certifying to DOE that their products and equipment comply with the applicable energy conservation standards adopted under EPCA, and for making other representations about the efficiency of those products. (42 U.S.C. 6293(c); 42 U.S.C. 6295(s); 42 U.S.C. 6314) Similarly, DOE must use these test procedures to determine whether such products and equipment comply with any relevant standards promulgated under EPCA. (42 U.S.C. 6295(s))

EPCA, as codified, 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 of any covered product type (or class) of

[2] All references to EPCA in this document refer to the statute as amended through the American Energy Manufacturing Technical Corrections Act (AEMTCA), Pub. L. 112-210 (Dec. 18, 2012).
[3] For editorial reasons, upon codification in the U.S. Code, Part C was redesignated Part A–1.

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))

EPCA prescribed energy conservation standards for consumer water heaters (42 U.S.C. 6295(e)(1)), and directed DOE to conduct further rulemakings to determine whether to amend these standards (42 U.S.C. 6295(e)(4)(A)-(B)). DOE notes that under 42 U.S.C. 6295(m), the agency must periodically review its already established energy conservation standards for a covered product. Under this requirement, the next review that DOE would need to conduct must occur no later than six years from the issuance of a final rule establishing or amending a standard for a covered product.

On April 16, 2010, DOE published a final rule (hereinafter referred to as the "April 2010 final rule") that amended the energy conservation standards for all classes of consumer water heaters, except for tabletop and electric instantaneous water heaters, for which the existing energy conservation standards were left in place. 75 FR 20112. The standards adopted by the April 2010 final rule are shown below in Table I.1. These standards will apply to all water heater products listed in Table I.1 and manufactured in, or imported into, the United States on or after April 16, 2015, for all classes, except for tabletop and electric instantaneous. For these latter two classes, compliance with these standards has been required since April 15, 1991. 55 FR 42162 (Oct. 17, 1990). Current energy conservation standards for consumer water heaters can be found in DOE's regulations at 10 CFR 430.32(d).

Table I.1 Energy Conservation Standards for Consumer Water Heaters

Product Class	Rated Storage Volume***	Energy Factor **
Gas-fired Storage	≥ 20 gal and ≤ 55 gal	0.675-(0.0015 x V_s)
	> 55 gal and ≤ 100 gal	0.8012-(0.00078 x V_s)
Oil-fired Storage	≤ 50 gal	0.68-(0.0019 x V_s)
Electric Storage	≥ 20 gal and ≤ 55 gal	0.96-(0.0003 x V_s)
	> 55 gal and ≤ 120 gal	2.057-(0.00113 x V_s)
Tabletop*	≥ 20 gal and ≤ 120 gal	0.93-(0.00113 x V_s)
Gas-fired Instantaneous	< 2 gal	0.82-(0.0019 x V_s)
Electric Instantaneous*	< 2 gal	0.93-(0.00132 x V_s)

*Tabletop and electric instantaneous standards were not updated by the April 2010 final rule.
**V_s is the "Rated Storage Volume" which equals the water storage capacity of a water heater (in gallons), as specified by the manufacturer.
***Rated Storage Volume limitations result from either a lack of test procedure coverage or from divisions created by DOE when adopting standards. The division at 55 gallons for gas-fired and electric storage water heaters was established in the April 16, 2010 final rule amending energy conservation standards. 75 FR 20112. The other storage volume limitations shown in this table are a result of test procedure applicability, and are discussed in the July 2014 final rule. 79 FR 40542 (July 11, 2014).

The initial Federal energy conservation standards and test procedures for commercial water heating equipment were added to EPCA as an amendment made by the Energy Policy Act of 1992 (EPACT). (42 U.S.C. 6313(a)(5)) These initial energy conservation standards corresponded to the efficiency levels contained in the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) Standard 90.1 (ASHRAE Standard 90.1) in effect on October 24, 1992. The statute provided that if the efficiency levels in ASHRAE Standard 90.1 were amended after October 24, 1992, the Secretary must establish an amended uniform national standard at new minimum levels for each equipment type specified in ASHRAE Standard 90.1, unless DOE determines, through a rulemaking supported by clear and convincing evidence, that national standards more stringent than the new minimum levels would

result in significant additional energy savings and be technologically feasible and economically justified. (42 U.S.C. 6313(a)(6)(A)(ii)(I)-(II)) DOE issued the most recent final rule for commercial water heating equipment on January 12, 2001 (hereinafter, the "January 2001 final rule"), which adopted the amended energy conservation standards at levels equivalent to efficiency levels in ASHRAE Standard 90.1, as it was revised in October 1999. 66 FR 3336. The current standards for commercial water heating equipment are presented in Table I.2 and may be found in DOE's regulations at 10 CFR 431.110.

Table I.2 Energy Conservation Standards for Commercial Water Heating Equipment

Equipment	Size	Energy Conservation Standard *	
		Minimum Thermal Efficiency	Maximum Standby Loss[c]
Electric storage water heaters	All	N/A	$0.30 + 27/V_m$ (%/hr)
Gas-fired storage water heaters	≤155,000 Btu/hr	80%	$Q/800+110(V_r)^{1/2}$ (Btu/hr)
	>155,000 Btu/hr	80%	$Q/800+110(V_r)^{1/2}$ (Btu/hr)
Oil-fired storage water heaters	≤155,000 Btu/hr	78%	$Q/800+110(V_r)^{1/2}$ (Btu/hr)
	>155,000 Btu/hr	78%	$Q/800+110(V_r)^{1/2}$ (Btu/hr)
Gas-fired instantaneous water heaters and hot water supply boilers**	<10 gal	80%	N/A
	≥10 gal	80%	$Q/800+110(V_r)^{1/2}$ (Btu/hr)
Oil-fired instantaneous water heaters and hot water supply boilers**	<10 gal	80%	N/A
	≥10 gal	78%	$Q/800+110(V_r)^{1/2}$ (Btu/hr)
Equipment	**Size**	**Minimum Thermal Insulation**	
Unfired hot water storage tank	All	R-12.5	

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

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

*** Water heaters and hot water supply boilers having more than 140 gallons of storage capacity need not

meet the standby loss requirement if: (1) the tank surface area is thermally insulated to R–12.5 or more; (2) a standing pilot light is not used; and (3) for gas or oil-fired storage water heaters, they have a fire damper or fan-assisted combustion.

On December 18, 2012, the American Energy Manufacturing Technical Corrections Act (AEMTCA), Public Law 112–210, was signed into law. In relevant part, it amended EPCA to require that DOE publish a final rule establishing a uniform efficiency descriptor and accompanying test methods for covered consumer water heaters and commercial water heating equipment within one year of the enactment of AEMTCA. (42 U.S.C. 6295(e)(5)(B)) The final rule must replace the current energy factor, thermal efficiency, and standby loss metrics with a uniform efficiency descriptor. (42 U.S.C. 6295(e)(5)(C)) The July 2014 final rule fulfilled these requirements. AEMTCA requires that, beginning one year after the date of publication of DOE's final rule establishing the uniform descriptor (*i.e.*, July 13, 2015), the efficiency standards for the consumer water heaters and residential-duty commercial water heaters identified in the July 2014 final rule must be denominated according to the uniform efficiency descriptor established in that final rule (42 U.S.C. 6295(e)(5)(D)), and that DOE must develop a mathematical conversion factor for converting the measurement of efficiency for those water heaters from the test procedures and metrics currently in effect to the new uniform energy descriptor. (42 U.S.C. 6295(e)(5)(E)(i)–(ii)) Consumer water heaters and residential-duty commercial water heaters manufactured prior to the effective date of the final rule (*i.e.*, July 13, 2015) that comply with the efficiency standards and labeling requirements in effect prior to the final rule shall be considered to comply with the final rule and with any revised labeling requirements established by the Federal Trade Commission (FTC) to carry out the final rule. (42 U.S.C. 6295(e)(5)(K))

AEMTCA also requires that the uniform efficiency descriptor and accompanying test method apply, to the maximum extent practicable, to all water-heating technologies currently in use and to future water-heating technologies. (42 U.S.C. 6295(e)(5)(H)) AEMTCA allows DOE to provide an exclusion from the uniform efficiency descriptor for specific categories of otherwise covered water heaters that do not have residential uses, that can be clearly described, and that are effectively rated using the current thermal efficiency and standby loss descriptors. (42 U.S.C. 6295(e)(5)(F))

AEMTCA outlines DOE's various options for establishing a new uniform efficiency descriptor for water heaters. The options that AEMTCA provides to DOE include: (1) a revised version of the energy factor descriptor currently in use; (2) the thermal efficiency and standby loss descriptors currently in use; (3) a revised version of the thermal efficiency and standby loss descriptors; (4) a hybrid of descriptors; or (5) a new approach. (42 U.S.C. 6295(e)(5)(G)) Lastly, AEMTCA requires that DOE invite stakeholders to participate in the rulemaking process, and that DOE contract with the National Institute of Standards and Technology (NIST), as necessary, to conduct testing and simulation of alternative descriptors identified for consideration. (42 U.S.C. 6295(e)(5)(I)–(J))

As noted previously, in the July 2014 final rule, DOE amended its test procedure for consumer and certain commercial water heaters. 79 FR 40542 (July 11, 2014). The July 2014 final rule for consumer and certain commercial water heaters satisfied the AEMTCA requirements to develop a uniform efficiency descriptor to replace the existing energy factor, thermal efficiency and standby loss metrics. The amended test procedure includes provisions for

determining the uniform energy factor (UEF), as well as the annual energy consumption of these products. Furthermore, the uniform descriptor test procedure can be applied to: (1) most consumer water heaters (including certain consumer water heaters that are covered products under EPCA's definition of "water heater" at 42 U.S.C. 6291(27), but that are not addressed by the existing test method); and (2) to commercial water heaters that have residential applications. The major modifications to the existing DOE test procedure to establish the uniform descriptor test method included the use of multiple draw patterns and different draw patterns, and changes to the set-point temperature. In addition, DOE expanded the scope of the test method to include test procedure provisions that are applicable to water heaters with storage volumes between 2 gallons (7.6 L) and 20 gallons (76 L), and to clarify applicability to electric instantaneous water heaters. DOE also established a new equipment class and corresponding definition for "residential-duty commercial water heater."

This rulemaking will satisfy the requirements of AEMTCA to develop a mathematical conversion factor for converting the measurement of efficiency for covered water heaters from the test procedures and metrics currently in effect to the new uniform energy descriptor. (42 U.S.C. 6295(e)(5)(E))

II. Summary of the Notice of Proposed Rulemaking

This notice of proposed rulemaking proposes to establish a mathematical conversion factor between the current rated values under the existing water heaters test procedures (*i.e.*, energy factor, first-hour rating, maximum gallons per minute (GPM) rating, thermal efficiency, standby loss), and the amended test procedure for the uniform efficiency descriptor (*i.e.*, UEF

and first-hour rating or maximum GPM rating), which was established in the July 2014 final rule. As discussed previously, the water heater test procedure was updated to be more representative of conditions encountered in the field (including modifications to both the test conditions and the draw patterns) and to expand the scope of the test procedure to apply to certain commercial and consumer water heaters that are currently not addressed by the test procedure.

The mathematical conversion factor required by AEMTCA is a bridge between the efficiency ratings obtained through testing under the existing test procedures and those obtained under the uniform efficiency descriptor test procedure published in the July 2014 final rule. Therefore, the mathematical conversion factor will only apply to products and equipment covered by the existing test procedure, as products and equipment that are not covered by the existing test method would not have ratings to be converted. Certain water heater types are not covered by the mathematical conversion factor, either because they are not covered by the uniform efficiency descriptor established by the July 2014 final rule (*e.g.*, commercial heat pump water heaters), or because they are not covered by DOE's existing test procedure (*e.g.*, water heaters with storage volumes between 2 and 20 gallons). The water heater types that are and are not covered by the mathematical conversion factor are discussed in detail in section III.B of this notice of proposed rulemaking.

To help develop the mathematical conversion factor, DOE conducted a series of tests on the types of water heaters included within the scope of this rulemaking (*i.e.*, those described in

section III.B and that pass the minimum standards for consumer[4] and commercial water heaters). An investigation of DOE's Compliance Certification Management System (CCMS) and the Air-Conditioning, Heating, and Refrigeration Institute's (AHRI) water-heating databases found that certain types of water heaters are not available for purchase on the market; these units are discussed in section III.B. As there are no existing water heaters in these product classes, and the purpose of the conversion factor is to convert the efficiency ratings of existing water heaters, DOE did not include these water heaters in its analysis for the mathematical conversion factor.

DOE selected 72 water heaters for testing, including: 43 consumer storage units, 22 consumer instantaneous units, and 7 commercial residential-duty storage units. Units were selected to represent the range of rated values available on the market (*i.e.*, storage volume, input rate, first-hour rating, maximum GPM, recovery efficiency, energy factor, thermal efficiency, and standby loss). DOE used data obtained from testing, along with analytical methods described in section III.C, to calculate the conversion factors described in this document. DOE investigated several approaches to derive these conversion factors, which are discussed in detail in section III.C of this notice of proposed rulemaking. DOE developed different conversion factors for determining first-hour rating, maximum GPM, and UEF based on the existing ratings for consumer and residential-duty commercial water heaters, which can be found in section III.E.

DOE then used the conversion factors to derive minimum energy conservation standards based on the UEF, as shown in Table II.1 and Table II.2. The proposed standards based on UEF are neither more nor less stringent than the existing standards for consumer water heaters based

[4] DOE published a final rule on April 16, 2010, that will require compliance with amended energy conservation standards beginning on April 16, 2015. 75 FR 20112. DOE focused the testing of consumer water heaters on units that would comply with the amended standards.

on energy factor (as amended by the April 2010 final rule) and for commercial water-heating equipment based on the thermal efficiency and standby loss metrics. The methodology for deriving the proposed UEF standards is discussed in detail in section III.E.3 of this notice of proposed rulemaking.

Table II.1 Proposed Consumer Water Heater Energy Conservation Standards

Product Class	Rated Storage Volume	Draw Pattern	Uniform Energy Factor*
Gas-fired Storage	≥ 20 gal and ≤ 55 gal	Very Small	$0.3263 - (0.0019\ x\ V_r)$
		Low	$0.5891 - (0.0019\ x\ V_r)$
		Medium	$0.6326 - (0.0013\ x\ V_r)$
		High	$0.7128 - (0.0025\ x\ V_r)$
	> 55 gal and ≤ 100 gal	Very Small	$0.5352 - (0.0007\ x\ V_r)$
		Low	$0.7375 - (0.0009\ x\ V_r)$
		Medium	$0.7704 - (0.0010\ x\ V_r)$
		High	$0.7980 - (0.0010\ x\ V_r)$
Oil-fired Storage	≤ 50 gal	Very Small	$0.2267 - (0.0014\ x\ V_r)$
		Low	$0.4867 - (0.0006\ x\ V_r)$
		Medium	$0.6016 - (0.0012\ x\ V_r)$
		High	$0.6529 - (0.0005\ x\ V_r)$
Electric Storage	≥ 20 gal and ≤ 55 gal	Very Small	$0.8268 - (0.0002\ x\ V_r)$
		Low	$0.9393 - (0.0004\ x\ V_r)$
		Medium	$0.9683 - (0.0007\ x\ V_r)$
		High	$0.9656 - (0.0004\ x\ V_r)$
	> 55 gal and ≤ 120 gal	Very Small	$1.2701 - (0.0011\ x\ V_r)$
		Low	$1.9137 - (0.0011\ x\ V_r)$
		Medium	$2.0626 - (0.0011\ x\ V_r)$
		High	$2.1858 - (0.0011\ x\ V_r)$
Tabletop Storage	≥ 20 gal and ≤ 100 gal	Very Small	$0.6808 - (0.0022\ x\ V_r)$
		Low	$0.8770 - (0.0012\ x\ V_r)$
		Medium	$0.9063 - (0.0009\ x\ V_r)$
		High	$0.9302 - (0.0006\ x\ V_r)$
Gas-fired Instantaneous	< 2 gal	All	$0.8036 - (0.0019\ x\ V_r)$
Electric Instantaneous	< 2 gal	All	$0.9192 - (0.0013\ x\ V_r)$

*V_r is the rated storage volume which equals the water storage capacity of a water heater (in gallons), as specified by the manufacturer.

Table II.2 Proposed Residential-Duty Commercial Water Heater Energy Conservation Standards

Product Class	Draw Pattern	Uniform Energy Factor
Gas-fired Storage	Very Small	$0.3261 - (0.0006\ x\ V_r)$
	Low	$0.5219 - (0.0008\ x\ V_r)$
	Medium	$0.5585 - (0.0006\ x\ V_r)$
	High	$0.6044 - (0.0005\ x\ V_r)$
Oil-fired Storage	Very Small	$0.3206 - (0.0006\ x\ V_r)$
	Low	$0.5577 - (0.0019\ x\ V_r)$
	Medium	$0.6027 - (0.0019\ x\ V_r)$
	High	$0.6446 - (0.0018\ x\ V_r)$

*V_r is the rated storage volume which equals the water storage capacity of a water heater (in gallons), as specified by the manufacturer.

EPCA requires that a covered water heater be considered to comply with the July 2014 final rule on and after July 13, 2015 (the effective date of the July 2014 final rule) and with any revised labeling requirements established by the Federal Trade Commission to carry out the July 2014 final rule if the covered water heater was manufactured prior to July 13, 2015, and complied with the efficiency standards and labeling requirements in effect prior to July 13, 2015. (42 U.S.C. 6295(e)(5)(K)) Upon the effective date of the final rule establishing the mathematical conversion factor (this rulemaking), compliance with energy conservation standards will be exclusively determined based on the standards as defined in terms of UEF, which will be established by this rulemaking. DOE has tentatively concluded that there will be three possible compliance paths available to manufacturers for basic models of consumer water heaters that were certified before July 13, 2015:

(1) Convert the certified rating for energy factor obtained using the test procedure contained in Appendix E to subpart B of 10 CFR part 430 of the January 1, 2015 edition of the CFR along with the applicable sampling provisions in 10 CFR part 429 from energy factor to uniform energy factor using the applicable mathematical conversion factor; or

(2) Conduct testing using the test procedure contained at Appendix E to subpart B of 10 CFR part 430, effective July 13, 2015, along with the applicable sampling provisions in 10 CFR part 429; or

(3) Where permitted, apply an alternative efficiency determination method (AEDM) pursuant to 10 CFR 429.70 to determine the represented efficiency of basic models for those categories of consumer water heaters where the "tested basic model" was tested using the test procedure contained at Appendix E to subpart B of 10 CFR part 430, effective July 13, 2015.

Similarly, DOE has tentatively concluded that there will be three possible compliance paths available to manufacturers for basic models of commercial residential-duty water heaters that were certified before July 13, 2015:

(1) Convert the certified rating for thermal efficiency and standby loss obtained using the test procedure contained in 10 CFR 431.106 of the January 1, 2015 edition of the CFR along with the applicable sampling provisions in part 429 from thermal efficiency and standby loss to uniform energy factor using the applicable mathematical conversion factor; or

(2) Conduct testing using the test procedure at 10 CFR 431.106, effective July 13, 2015, along with the applicable sampling provisions in part 429; or

(3) Where permitted, apply an alternative efficiency determination method (AEDM) pursuant to 10 CFR 429.70 to determine the represented efficiency of basic models for those categories of commercial water heaters where the "tested basic model" was tested using the test procedure at 10 CFR 431.106, effective July 13, 2015.

After July 13, 2015, all new basic models (previously uncertified) must be rated using the new test procedure either by testing or by an AEDM, where allowed. All water heaters subject to the new test procedure adopted by the July 2014 final rule must be rated and certified in terms of UEF. DOE will assess compliance based upon the energy conservation standards expressed in terms of UEF as developed in this rulemaking. One year after the final rule in this rulemaking is published, all water heaters subject to the new UEF test procedure must be rated and certified based on testing using the UEF test procedure or an AEDM, which is based on the UEF test procedure, where allowed. A summary of the options and requirements at various key dates is shown in the table below.

Table II.3 Summary of Key Dates and Requirements

Description of Date	**Date**	**Requirements**
Test Procedure Effective Date	July 13, 2015	For new basic models introduced into commerce on or after July 13, 2015, manufacturers must begin to test and represent efficiency using the UEF metric pursuant to the UEF test procedure and sampling plan (or an AEDM that is based on the UEF test procedure, where allowed).
Conversion Factor Effective Date	Date of publication of the conversion factor final rule in the *Federal Register*	For basic models certified using the EF metric or thermal efficiency and/or standby loss metrics prior to July 13, 2015, manufacturers must transition all of their representations to UEF either by applying the conversion equations or by using the UEF test procedure and sampling plan (or an AEDM that is based on the UEF test procedure, where allowed).
Conversion Factor Ending Date	One year after publication of conversion factor final rule	All basic models must be rated in terms of UEF using the UEF test procedure and sampling plan or an AEDM that is

		based on the UEF test procedure, where allowed.

III. Discussion

A. Stakeholder Comments on Other Rulemakings

During the rulemaking process to develop the uniform efficiency descriptor test procedure, comments were received from stakeholders in reference to the derivation and applicability of the conversion factor. DOE deferred discussion of and response to those comments until such time as they could be addressed in this rulemaking.

In response to the test procedure request for information (RFI[5]) published on January 11, 2013, DOE received seven written comments related to the conversion factor from the following interested parties: AHRI, A.O. Smith Corporation (A.O. Smith), Edison Electric Institute (EEI), Heat Transfer Products Inc. (HTP), the National Renewable Energy Laboratory (NREL), the Northwest Energy Efficiency Alliance (NEEA), and a joint comment on behalf of a number of environmental groups and efficiency advocates submitted by the American Council for an Energy-Efficient Economy (ACEEE).[6] These comments are discussed immediately below.

NREL stated that there is not a simple conversion factor that will work across all systems, but suggested an application of the Water Heater Analysis Model (WHAM)[7] to assist DOE in

[5] 78 FR 2340.

[6] ACEEE submitted a joint comment on behalf of ACEEE, the Appliance Standards Awareness Project (ASAP), the Alliance to Save Energy (ASE), the National Consumer Law Center (NCLC), the National Resources Defense Council (NRDC), the Northwest Power and Conservation Council (NPCC), and the Northeast Energy Efficiency Partnerships (NEEP).

[7] Lutz, Jim, Camilla D. Whitehead, Alex Lekov, David Winiarski, and Greg Rosenquist, *WHAM: A Simplified Energy Consumption Equation for Water Heaters*, Proc. of 1998 ACEEE Summer Study on Energy Efficiency in Buildings. Vol. 1. 171-83. Print.

developing the conversion factor for storage water heaters. (NREL, EERE-2011-BT-TP-0042-0029 at p. 4) The joint commenters supported the use of a "good-enough" mathematical conversion method to express existing ratings in terms of the new uniform descriptor and urged DOE to test a sample of existing products to validate the algorithmic conversion method. (Joint comment, EERE-2011-BT-TP-0042-0035 at p. 4) HTP commented that the most exact approach would be to conduct an empirical analysis using curve fitting to actual test data, although the commenter acknowledged that there is not sufficient time for manufacturers to obtain this information and for the Department to then correlate and analyze the data. (HTP, EERE-2011-BT-TP-0042-0041 at p. 3)

Regarding the derivation of updated energy conservation standards using the new uniform descriptor, AHRI and A.O. Smith commented that DOE should not simply test multiple units to determine an average difference between the current and new ratings and use that value to convert the ratings. (AHRI, EERE-2011-BT-TP-0042-0033 at p. 4; A.O. Smith, EERE-2011-BT-TP-0042-0034 at p. 3) NEEA commented that considering the limited laboratory capacity to test all water heaters under the revised method of test, DOE should assume that all water heaters that comply with current standards will also comply after the implementation of the new metrics. (NEEA, EERE-2011-BT-TP-0042-0037 at p. 6) EEI commented that the conversion factor should not make currently existing standards more stringent and should only be based on point-of-use metrics to be consistent with Federal law. (EEI, EERE-2011-BT-TP-0042-0040 at p. 2)

In response to the test procedure NOPR[8] published on November 4, 2013, DOE received three additional written comments related to the conversion factor from: AHRI, Bradford White Corporation (BWC) and a joint comment submitted on behalf of a number of environmental groups and efficiency advocates by ACEEE.[9] AHRI and BWC suggested model types to test and urged DOE to release a schedule and process for the development of the conversion factor as soon as possible. (AHRI, EERE-2011-BT-TP-0042-0075 at p. 6-7; BWC, EERE-2011-BT-TP-0042-0061 at p. 7) AHRI suggested two categories to be considered in the conversion factor rulemaking: water heater type and storage volume. BWC expanded on the list of categories supplied by AHRI by including considerations for input capacity, venting options, tank configuration, NO_X emissions, and mobile home certification. The joint comment suggested that the sensitivity of the energy factor to draw pattern be investigated and that systematic differences between "old" and "new" values should be expected for several technologies. (Joint Comment, EERE-2011-BT-TP-0042-0077 at p. 2)

DOE has considered these comments fully in the development of this proposed rule. Although discussed in overview here, these comments are discussed in more detail later in this document as applicable to DOE's specific decisions regarding the mathematical conversion factor. In regards to the method of developing the conversion factor, DOE agrees in principle with the HTP comment that the most exact approach would be an empirical analysis using a curve-fitting method and actual test data, because such approach would account for all the changes made in the new test procedure, without having to make assumptions. However, DOE notes that the confidence in this empirical approach is dependent upon sample size and has

[8] 78 FR 66202.
[9] ACEEE submitted a joint comment on behalf of ACEEE, ASAP, ASE, Consumers Union (CU), NCLC, NRDC and NEEP.

considered whether the approach can feasibly be tested and implemented within the time constraints set forth by AEMTCA. (The curve-fitting method investigated is discussed in section III.C.3.)

In addition, as suggested by NREL, DOE investigated the use of the WHAM model to predict water heater efficiency under the new test procedure parameters, and used the results in the conversion factor analysis. The methodology for applying WHAM and the results are found in section III.C.2.c. As suggested in the NOPR joint comment, the sensitivity of the UEF to draw pattern was investigated by including the drawn volume in the conversion factor calculations; this approach is discussed further in section III.C.

In an effort to develop a mathematical conversion factor, DOE commissioned testing of 72 individual water heaters from various easily distinguishable water-heating categories under the updated test procedure. All of the water heaters chosen were found using either the Compliance Certification Management System (CCMS) or AHRI water heater databases, where the water heaters included in the databases were further distinguished based on the suggestions made by AHRI and BWC in response to the November 2013 water heaters NOPR (78 FR 66202 (Nov. 4, 2013)). The models selected for testing and the parameters examined are described in more detail in section III.D. These test data were used to investigate all of the potential conversion factor methods described in section III.C.

DOE has also carefully considered the comments regarding the establishment of energy conservation standards using the uniform efficiency descriptor metric (*i.e.*, UEF). Those comments are discussed further in section III.E.3.

B. Scope

The purpose of this section is to describe DOE's process for categorizing water heaters and establishing the range of units to be considered in this mathematical conversion factor rulemaking. DOE seeks comment on the scope of the conversion factor. This is identified as issue 1 in section V.E, "Issues on Which DOE Seeks Comment."

1. Test Procedure and Energy Conservation Standards Coverage

To determine the appropriate scope of coverage for the mathematical conversion factor, DOE first considered the scope of its existing test procedures and energy conservation standards for consumer and commercial water heaters. Water heaters that are not currently subject to the DOE test procedures or standards were not included in the scope of the conversion factor, as they are not required to be tested and rated for efficiency under the DOE test method.

a. Consumer Water Heaters

Under the existing regulatory definitions, DOE's current consumer water heater test procedures and energy conservation standards are not applicable to gas or electric water heaters with storage tanks that are at or above 2 gallons (7.6 L) and less than 20 gallons (76 L). In terms of the high end of the capacity range, the current DOE test procedure for consumer water heaters only applies to gas-fired water heaters with storage volumes less than or equal to 100 gallons

(380 L), electric resistance and heat pump storage water heaters with storage volumes less than or equal to 120 gallons (450 L), and oil-fired water heaters with storage volumes less than or equal to 50 gallons (190 L). 10 CFR part 430, subpart B, appendix E, sections 1.12.1, 1.12.2, and 1.12.4.

In the July 2014 final rule, DOE expanded the scope of the water heater test procedure for the uniform efficiency descriptor to include water heaters with storage volumes between 2 and 20 gallons and up to 120 gallons. 79 FR 40542, 40547-48 (July 11, 2014).

DOE's current consumer water heater test procedure and energy conservation standards are not applicable to gas-fired instantaneous water heaters with input capacities at or below 50,000 Btu/h or at or above 200,000 Btu/h. 10 CFR Part 430, subpart B, appendix E, section 1.7.2. In addition, the existing test procedure and energy conservation standards are not applicable to gas-fired storage water heaters with input capacities above 75,000 Btu/h, electric storage water heaters with input ratings above 12 kW, and oil-fired storage water heaters with input ratings above 105,000 Btu/h, as models exceeding those limits would not be classified as consumer water heaters under EPCA. (42 U.S.C. 6291(27)); 10 CFR Part 430, subpart B, appendix E, sections 1.12.1, 1.12.2, and 1.12.4.

In the July 2014 final rule, DOE designed the test procedure so it is applicable to water heaters with any input capacity. Therefore, the lower limit for instantaneous water heaters no longer applies. 79 FR 40542, 40548 (July 11, 2014).

As discussed in the July 2014 final rule, definitions were added for "electric instantaneous water heater," "gas-fired heat pump water heater," and "oil-fired instantaneous water heater," and the July 2014 test procedure is applicable to these types of appliances. 79 FR 40542, 40549 (July 11, 2014).

Although there is no definition for "electric instantaneous water heater" in the current test procedure in 10 CFR part 430, subpart B, Appendix E, an energy conservation standard exists for this type of water heater. In addition, the current test procedure can be applied to electric instantaneous water heaters, and manufacturers report energy factor ratings for these products. For these reasons, DOE has decided to include electric instantaneous water heaters with rated storage volumes < 2 gallons and rated inputs ≤ 12 kW in the conversion factor analysis.

DOE has tentatively excluded the consumer water heater products listed in Table III.1 from consideration for the mathematical conversion factor due to the lack of an existing Federal test procedure and rating to be converted.

Table III.1 Consumer Water Heaters Not Covered by the Mathematical Conversion Factor

Product Class	Description of Criteria for Exclusion from Conversion Rulemaking
Gas-fired Storage	Rated Storage Volume ≥ 2 gal and < 20 gal or > 100 gal and ≤ 120 gal
Oil-fired Storage	Rated Storage Volume > 50 gal
Electric Storage	Rated Storage Volume ≥ 2 gal and < 20 gal
Tabletop	Rated Storage Volume ≥ 2 gal and < 20 gal
Gas-fired Instantaneous	Rated Input ≤ 50,000 Btu/h ; Rated Storage Volume > 2 gal
Electric Instantaneous	Rated Storage Volume > 2 gal

b. Commercial Water Heaters

As stated in the July 2014 final rule, DOE excluded from the uniform efficiency descriptor any specific category of water heater that does not have a residential use, can be clearly described, and can be effectively rated using the current thermal efficiency and standby loss descriptors. 79 FR 40542, 40545 (July 11, 2014). DOE determined that certain commercial water heaters met these criteria to be excluded from the uniform efficiency descriptor, and distinguished them from water heaters that do not meet the criteria by establishing equipment classes for residential-duty commercial water heaters. Commercial water heaters meeting the definition of "residential-duty commercial water heater" do not meet the criteria for exclusion, and thus, are included in the uniform efficiency descriptor while all other commercial water heaters are not. DOE determined that three criteria would be used to distinguish residential-duty commercial water heaters from other commercial water heaters (79 FR 40542, 40547 (July 11, 2014)):

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

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

(3) Is not excluded by the limitations regarding rated input and storage volume presented in Table III.2.

Table III.2 Capacity Limitations for Defining Commercial Water Heaters Without Residential Applications (*i.e.*, Non-Residential-Duty)

Water Heater Type	Indicator of non-residential application
Gas-fired Storage	Rated input >105 kBtu/h; Rated storage volume >120 gallons
Oil-fired Storage	Rated input >140 kBtu/h; Rated storage volume >120 gallons
Electric Storage	Rated input >12 kW; Rated storage volume >120 gallons
Heat Pump with Storage	Rated input >15 kW; Rated current >24 A at a rated voltage of not greater than 250 V; Rated storage volume >120 gallons
Gas-fired Instantaneous	Rated input >200 kBtu/h; Rated storage volume >2 gallons
Electric Instantaneous	Rated input >58.6 kW; Rated storage volume >2 gallons
Oil-fired Instantaneous	Rated input >210 kBtu/h; Rated storage volume >2 gallons

DOE did not include commercial water-heating equipment that does not meet the definition of a "residential-duty commercial water heater" in its consideration of the mathematical conversion factor, as the equipment is not subject to the uniform efficiency descriptor test procedure. Additionally, DOE notes that there are no electric storage water heaters that would be considered to be residential-duty commercial since the qualifications shown in Table II.2 would place an electric storage water heater in the consumer category. Since there are no such units, and could not be such units under the applicable definition, a conversion is unnecessary. DOE is, therefore, not proposing a conversion factor for residential-duty electric storage water heaters. DOE also notes that a water heater that meets the definition of a consumer electric storage water heater must be tested and rated as a consumer electric storage water heater even if it is marketed as part of a commercial product line.

As stated in the July 2014 final rule, DOE has determined that certain commercial equipment including unfired storage tanks, add-on heat pump water heaters, and hot water supply boilers are not appropriately rated using the uniform descriptor applicable to other water heaters, and, thus, will continue to be rated using the existing metrics. 79 FR 40542, 40547.

Electric instantaneous water heaters are currently subject to the commercial water heating equipment test procedures but do not have an associated energy conservation standard. 10 CFR 431.106; 10 CFR 431.110. Because there is no commercial energy conservation standard for electric instantaneous water heaters, a conversion to the UEF cannot be made.

2. Units on the Market

As stated in section II, DOE undertook an investigation into the water-heating units on the market at the time of the publication of the final rule establishing the UEF test procedure. The AHRI commercial water heater database along with the CCMS consumer water heater database were examined to select representative units for testing and analysis.

DOE's analysis focused on the models that meet the energy conservation standards contained in the April 2010 final rule, which will require compliance on April 16, 2015. The storage volume divisions at 55 gallons in the gas-fired and electric storage product classes, as established in the April 16, 2010 final rule, represent a divide in technology. For gas-fired storage units above 55 gallons manufactured on and after April 16, 2015, the energy conservation standard will be high enough that current designs can only achieve the required

efficiency through the use of condensing technology.[10] For electric storage units with storage volumes above 55 gallons, only heat pump water heaters currently have the ability to reach the April 16, 2015 energy conservation standard levels. While the UEF test procedure will apply to both electric and gas units in this range, DOE found that for gas-fired storage water heaters, there are currently no consumer water heaters above 55 gallons that would be compliant with the updated standard, so no units were tested for development of a conversion factor. For electric storage water heaters, heat pump water heaters meet or exceed the amended energy conservation standards and, thus, were candidates for inclusion in the test plan for the conversion factor. There are no oil-fired instantaneous or oil-fired storage water heaters above 50 gallons available on the market.

In reviewing the commercial water heating market, DOE found that commercial oil-fired instantaneous water heaters are available on the market but do not meet the definition of "residential-duty commercial water heater," as they have storage volumes greater than 2 gallons. DOE found that all commercial gas-fired instantaneous units exceeded the maximum delivery temperature of 180 °F for residential-duty commercial water heaters, and, thus, would be regulated using the existing thermal efficiency and standby loss metrics. DOE also found that commercial electric instantaneous units which meet the definition of "residential-duty commercial water heater" exist, however, as stated in section III.B.1.b, no energy conservation standard exists for these units; therefore a conversion factor was not developed.

[10] In a condensing water heater, the combustion gases are cooled such that the temperature is reduced below the dew point and condensation occurs, allowing the latent heat of vaporization to be captured and improving the efficiency of the heat exchange between the combustion gases and the water.

Consequently, none of the commercial water heaters identified above could be tested or examined for use in this rulemaking. In addition, a conversion factor for these water heaters is not needed because there are no units in existence with efficiency ratings that can be converted. However, because a manufacturer may want to design and produce products in these equipment classes in the future, DOE must establish energy conservation standards in terms of the UEF metric. Accordingly, DOE used information gained from other product classes to establish these energy conservation standards, as discussed in section III.E.

C. Potential Approaches for Developing Conversions

1. Background Regarding Changes to Existing Test Procedures

a. Consumer Water Heater Test Procedures

Both the current test procedure and the uniform efficiency descriptor test procedure consist of a delivery capacity test and a 24-hour simulated-use test. The delivery capacity tests for storage and instantaneous water heaters are the first-hour rating and maximum GPM tests, respectively. These tests are largely unchanged from the current to the new test procedure, except for modifications to account for the decrease in delivered water temperature from a nominal value of 135 °F to 125 °F. The results of those tests, however, have implications on the 24-hour simulated-use test under the new test procedure that are absent under the current test procedure.

In the current test procedure, the delivery capacity has no effect on the 24-hour simulated-use test, which consists of six hot water draws, of equivalent volumes, at the start of the test and each of the first five subsequent hours. The water heater is then in standby mode for

the remainder of the test. In the July 2014 final rule, however, the delivery capacity determines the draw pattern for the 24-hour simulated-use test. According to the new test procedure, a water heater's delivery capacity can be categorized as either very small, low, medium, or high; these usages are shown below in Table III.3. 79 FR 40542, 40572 (July 11, 2014). These usage categories have an associated draw pattern prescribed to them during the 24-hour simulated-use. Depending on the delivery capacity associated with a water heater, between 9 and 14 hot water draws of various volumes and flow rates are required.

Table III.3 Delivery Capacity Categorization Criteria

Draw Pattern	First-Hour Rating, gal		Maximum GPM, gpm		Drawn Volume, gal
	≥	<	≥	<	
Very Small	0	18	0	1.7	10
Low	18	51	1.7	2.8	38
Medium	51	75	2.8	4	55
High	75	No upper limit	4	No upper limit	84

In the existing DOE consumer water heater test procedure, a temperature of 135 °F ± 5 °F is used for the set-point temperature for storage water heaters (measured as the mean tank temperature) and the delivery temperature for instantaneous water heaters. In the uniform efficiency descriptor test procedure set forth in the July 2014 final rule, a temperature of 125 °F ± 5 °F is used for the set-point temperature for storage water heaters (measured as the delivery temperature) and the delivery temperature of instantaneous water heaters. 79 FR 40542, 40554 (July 11, 2014).

b. Commercial Water Heater Test Procedure

The current test procedure for rating commercial water heaters consists of a steady-state test to determine thermal efficiency and a test lasting between 24 and 48 hours to measure the standby loss. 77 FR 28996 (May 16, 2012); 10 CFR 431.106. For electric resistance water heaters, the thermal efficiency is assigned a value of 98 percent in lieu of testing. The set-point temperature of the water heater is 140 °F ± 5 °F, and the unit sits in an environment with an ambient temperature of 75 °F ± 10 °F. Water is supplied to the water heater at a temperature of 70 °F ± 2 °F. Instantaneous water heaters are not required to undergo a standby loss test.

Under the uniform efficiency descriptor test procedure, commercial water heaters falling under the "residential-duty" category will now be subject to the first-hour rating or maximum GPM test and simulated-use tests specified in the previous section (III.C.1.a), with the same set-point temperature, ambient temperature, and inlet water temperature as is applied to consumer water heaters.

2. Analytical Methods

For converting existing ratings to ratings under the uniform efficiency descriptor test method, DOE considered equations based on a water heater's physical characteristics; these approaches will be termed analytical methods. The sections below describe potential analytical methods for the three key metrics that result from the uniform efficiency descriptor test method: (1) the maximum GPM; (2) the first-hour rating; and (3) the UEF. In the discussion immediately below, DOE introduces key factors that it expects will change ratings from the existing consumer

and commercial water heater test procedures to the new uniform efficiency descriptor test procedure.

a. Maximum GPM

For flow-activated water heaters, the delivery capacity is determined by the 10-minute maximum GPM rating test. During this test, the water heater runs at maximum firing rate to raise the temperature from its nominal value of 58 °F to the prescribed delivery temperature. This flow rate is determined by the following equation:

$$\dot{V} = \frac{Q \cdot \eta_r}{\rho c_p (T_{del} - T_{in})}$$

where $\dot{V}$ is the volumetric flow rate of water, Q is the firing rate, η_r is the recovery efficiency, ρ is the density of the delivered water, c_p is the specific heat of the delivered water, T_{del} is the delivered water temperature, and T_{in} is the inlet water temperature. If it is assumed that the firing rate and recovery efficiency are the same with water delivered at 125 °F and 135 °F, then the ratio of the maximum GPM at 125 °F versus that at 135 °F is determined by the following equation:

$$\frac{\dot{V}_{125}}{\dot{V}_{135}} = \frac{(\rho c_p)_{135}(135°\text{F} - 58°\text{F})}{(\rho c_p)_{125}(125°\text{F} - 58°\text{F})} = 1.147$$

Therefore, an analytical conversion from the existing maximum GPM rating ($\dot{V}_{ex}$) for consumer water heaters to the rating under the test conditions in the uniform efficiency descriptor test method ($\dot{V}_{UED}$) is:

$$\dot{V}_{UED} = 1.147\dot{V}_{ex}$$

As discussed in detail in section III.E.2, tests on flow-activated water heaters showed a change in maximum GPM rating under the uniform efficiency descriptor test method that correlated well with the above equation.

b. First-Hour Rating

For water heaters that have a heat source controlled by means other than sensing flow (*e.g.*, thermostatically-controlled), the delivery capacity is determined through a first-hour rating test. During this test, the water heater begins in its fully heated state, and water is drawn from it at a specified flow rate until the temperature of the delivered water drops a specified amount. The water heater is then allowed to recover, and subsequent draws are initiated when the controller acts to reduce the heat input to particular burners or heating elements specified in the test procedure. These subsequent draws are terminated based on the same criterion that is used for the first draw, namely that the outlet water temperature drops a set amount of degrees from its maximum value during that draw. When the test reaches a duration of one hour from the start of the first draw, the test concludes after the draw termination criterion is reached for the draw taking place at one hour from the start of the test. If no draw is occurring at the one hour duration, a draw is initiated and terminated when the outlet water temperature reaches the

termination temperature of the previous draw, and the test is concluded upon termination of that draw.

In the uniform efficiency descriptor test procedure, the primary change that will affect the first-hour rating is the shift from a nominal delivery temperature of 135 °F to 125 °F and the accompanying adjustment to the draw termination criterion to a decrease in delivered water temperature from 25 °F in the current consumer water heater test method to 15 °F in the uniform efficiency descriptor test method. Because the initial set-point temperature is reduced in the uniform efficiency descriptor as compared to the existing consumer water heater test procedure, less stored thermal energy will be available at the start of the test. However, this effect is countered because the lower set-point temperature allows the water heater to recover quicker (as the water only needs to be heated to a 15 °F temperature rise rather than a 25 °F temperature rise), thereby allowing subsequent draws to start sooner than they would under the current test procedure. Thus, due to these offsetting effects, DOE has observed through testing that sometimes the first-hour rating is increased when tested under the uniform efficiency descriptor, and sometimes the rating is decreased. DOE is not aware of any analytical models that would mathematically represent this behavior, so it has chosen not to pursue such an approach for converting existing first-hour ratings to first-hour ratings under the uniform efficiency descriptor. Rather, as discussed in section III.C.3, DOE chose an approach based on an empirical regression for converting the first-hour ratings.

Likewise, DOE is not aware of any analytical method that will convert rated values of thermal efficiency and standby loss for residential-duty commercial storage water heaters to a

first-hour rating. Therefore, DOE chose an approach based on empirical regression for converting existing ratings of residential-duty commercial water heaters to first-hour ratings.

c. Uniform Energy Factor

A number of changes to the 24-hour simulated-use test will alter the water heater energy efficiency ratings from the existing water heater test procedures as compared to the ratings obtained under the uniform efficiency descriptor test method. Among the key changes that are expected to alter the efficiency metric for consumer water heaters are: (1) a different volume of water withdrawn per test; (2) a change in the draw pattern (*i.e.*, number of draws, flow rates during draws, timing of draws) applied during the test; (3) reduction of the test temperature from an average stored temperature of 135 °F to a delivered water temperature of 125 °F; and (4) removal of the stipulation to normalize the energy consumption to maintain a prescribed average water temperature within the storage tank. Residential-duty commercial water heaters will see a change from the thermal efficiency and standby loss metrics currently in place to the UEF, which consists of an entirely new approach for rating efficiency.

i. Consumer Storage Water Heaters

A simple theoretical model for determining the energy consumption of a storage-type water heater based on key test parameters, termed the Water Heater Analysis Model (WHAM), was presented by Lutz *et al*.[11] The equation for the energy input (Q) over a 24-hour period is determined using the following equation:

[11] Lutz, Jim, Camilla Dunham Whitehead, Alex Lekov, David Winiarski, and Greg Rosenquist. "WHAM: A Simplified Energy Consumption Equation for Water Heaters" In *Proceedings of the 1998 ACEEE Summer Study on Energy Efficiency in Buildings* (1998) (Available at: http://cgec.ucdavis.edu/ACEEE/1998/pdffiles/papers/0114.pdf) (Last accessed October 1, 2014).

$$Q = \frac{\rho c_p V(T_{del} - T_{in})}{\eta_r}\left(1 - \frac{UA(T_{tank} - T_{amb})}{P}\right) + 24 \cdot UA \cdot (T_{tank} - T_{amb})$$

where ρ is the density of water, c_p is the specific heat of water, η_r is the recovery efficiency, V is the volume of water delivered per day, UA is the heat loss factor, T_{tank} is the average temperature of the water stored within the tank of a storage water heater, P is the input power to the water heater in Btu/h, T_{amb} is the average ambient temperature during the test, and 24 is the number of hours in the test. This equation considers the energy required to heat the water that is delivered by the water heater from the inlet water temperature up to the delivery temperature and the energy required to make up the heat lost from the water heater to the surrounding environment. The time over which this standby energy loss is determined is corrected by the term with the power in the denominator to account for the fact that η_r, as calculated in the test, accounts for standby energy loss during periods when heat input to the water is activated.

This calculated energy can then be used to estimate the daily efficiency, Eff, under a given daily water demand (*e.g.*, that required during the current EF test or that required during the UEF test):

$$Eff = \frac{\rho c_p V(T_{del} - T_{in})}{Q}$$

Currently, directories of water heater ratings provide the Eff (*i.e.*, Energy Factor), P, and η_r. Since the EF testing entails a prescribed T_{del} (135 °F), T_{in} (58 °F), T_{tank} (135 °F), T_{amb} (67.5 °F), and V (64.3 gallons), the two equations can be solved for the two remaining unknowns, Q

and UA. The exception to this approach is heat pump water heaters. For these units, the reported recovery efficiency (η_r) is that of the resistance element inside the water heater. Since it is expected that the heat pump unit would provide the majority of the heating during the simulated-use test as opposed to the resistance element, the required data to use the WHAM model for heat pump water heaters is not readily available in publicly accessible directories. For these units, DOE proposes to base the conversion equation purely on experimental data.

After the equations are solved to determine UA, if one assumes that the UA and η_r do not change under the new test approach, then the two equations can be solved again (this time inserting the UA value obtained from solving the previous set of equations) to determine the values for Q and Eff (*i.e.*, UEF) under the uniform efficiency descriptor test method using the prescribed values for the uniform efficiency descriptor test procedure of T_{del} (125 °F), T_{in} (58 °F), T_{tank} (125 °F), T_{amb} (67.5 °F), and V (varies depending upon draw pattern).

This formulation entails a number of assumptions. A major assumption is that the average tank temperature is approximately equal to the delivered water temperature. As previously noted, the new procedure does not normalize the average stored water temperature to a prescribed value, so this estimate may not be completely accurate. Some water heaters have demonstrated that average tank temperature is below the typical delivered temperature because of stratification. This effect is believed to be most pronounced with condensing water heaters. Other water heaters show some stratification, but the average water temperature within the tank is typically closer to the delivered water temperature. Another assumption in this formulation is that the recovery efficiency and UA values do not change when the water heater stores water for

delivery at 135 °F compared to storing it at 125 °F. While electric resistance water heaters have a prescribed recovery efficiency of 98 percent, other technologies may see changes in the recovery efficiency as the temperature drops. For example, the study by Sparn *et al.* shows plots of the Coefficient of Performance (COP), which is one aspect of the recovery efficiency, for heat pump water heaters.[12] Their data suggest an increase in COP of approximately 15 percent with the average tank temperature at 125 °F compared to 135 °F. Data obtained by DOE indicate an increase in recovery efficiency obtained during the same draw profile of between 3 and 13 percent, with an average of 8 percent. Data collected on fossil-fuel-fired water heaters show negligible dependency of the recovery efficiency on the prescribed tank temperature. The UA value may change slightly based on higher heat transfer coefficients at higher temperatures or changes in the thermal conductivity of insulating materials at higher temperatures. Data collected by DOE suggest that the UA value decreases 7 percent from 135 °F to 125 °F.

For an initial estimate, DOE considered the situation where the UA and recovery efficiency do not change with temperature. The equations above can estimate the effects of two key factors that have changed in the test procedure, namely the volume drawn per day and the delivery temperature. As more water is delivered, the fraction of energy required to make up the standby losses compared to the overall energy required by the water heater is diminished, thereby increasing the fraction of energy going towards hot delivered water and increasing the efficiency. The change in set-point temperature appears to have less of an effect on water heater efficiency, since two competing factors are at play. With a lower stored water temperature, the

[12] Sparn, B., K. Hudon, and D. Christensen, *Laboratory Performance Evaluation of Residential Integrated Heat Pump Water Heaters*. National Renewable Energy Laboratory (September 2011) (Available at: http://www.nrel.gov/docs/fy11osti/52635.pdf) (Last accessed October 1, 2014).

standby losses are decreased, thereby increasing the overall efficiency of the water heater. The lower delivery temperature, however, means that less energy is delivered per gallon, so the energy delivered for a given volume delivered per day is less than that when the water is delivered at 135 °F, thereby decreasing the efficiency of the water heater.

As noted, direct use of this model may not properly account for changes to the recovery efficiency, UA value, or normalization procedure for standby heat loss. Therefore, DOE has chosen a two-step process to convert the existing Energy Factor ratings for consumer storage water heaters to the UEF. First, using the equations and assumptions described above, a prediction of the efficiency given by WHAM is determined, termed UEF_{WHAM}. This value is then considered as part of a regression analysis (see section III.C.3) to obtain a relationship that will convert from EF to UEF. DOE believes that the use of WHAM will capture the primary effects of changes in the volume of water delivered per day along with changes in the set-point temperature. Regression with experimental data will then capture the effects that may not be fully accounted for by WHAM, such as differences in the UA value, recovery efficiency, and the change to the normalization calculation procedure for standby heat loss.

To establish a clear method of applying the analytical model, the WHAM-based UEF equation and Table III.4, comprising the coefficients based on draw bin, are presented below. This equation incorporates the equations and assumptions presented above, where η_r and EF are the recovery efficiency and energy factor, respectively, based on the current DOE test procedure, and P is the nameplate input rate in Btu/h. As shown in **Table** III.4, constants "a," "b," "c," and "d" are dependent on the volume of water being drawn.

$$\mathrm{UEF_{WHAM}} = \left[\frac{1}{\eta_r} + \left(\frac{1}{\mathrm{EF}} - \frac{1}{\eta_r}\right)\left(\frac{\mathrm{a\ P}\ \eta_r - \mathrm{b}}{\mathrm{c\ P}\ \eta_r - \mathrm{d}}\right)\right]^{-1}$$

Table III.4 Coefficients for WHAM-based UEF Conversion Factor

Draw Bin	a	b	c	d
Very Small	56095146	12884892499	8930623	15125743368
Low	56095146	48962591496	33936368	57477824799
Medium	56095146	70866908744	49118427	83191588525
High	56095146	108233096990	75017235	127056244293

ii. Consumer Instantaneous Water Heaters

WHAM is not directly applicable to instantaneous water heaters because it assumes that the water heater loses heat at a constant rate throughout the day when the heating element is not energized. For instantaneous water heaters, this modeling approach is inappropriate since the unit does not store water at an elevated temperature throughout the day, rather heating water as it flows through the unit.

Instantaneous water heaters instead experience a separate type of heat loss to the surroundings that sometimes result in Energy Factors that are below the steady-state thermal efficiency. This loss occurs when heat that is present in the water heater at the end of a draw

dissipates to the ambient. If a draw is not initiated shortly after the end of a draw, then most of this heat is lost. If, however, a subsequent draw starts shortly after a previous draw, some of that heat is captured in the hot water that is delivered.

DOE attempted to capture these effects in a modified equation that separately accounts for energy consumption that goes towards supplying heat to the delivered water and energy consumption that goes towards heating up the materials making up the water heater:

$$Q = \frac{\rho c_p V (T_{del} - T_{in})}{\eta_r} + LF \cdot N^* \cdot (T_{del} - T_{amb})$$

where LF is a loss factor related to the amount of energy stored in the materials of the water heater and N* is the number of draws from which heat loss occurs to the environment. LF is approximately equal to the mass of the material within the water heater times its heat capacity. N* is not simply the number of draws during the day, since some draws may occur close together and do not result in total energy loss. To determine the fraction of energy from a draw that is lost, DOE examined data from testing that suggested that most heat is lost from tankless water heaters after about one hour. Using this value, DOE scaled the energy loss for a draw by the length of the standby time following the draw. For example, a draw followed by over one hour of standby time would contribute a value of 1 to N* for that test. A draw followed by 30 minutes of standby time prior to the next draw would contribute a value of (30 min)/(60 min) = 0.5 to N*. Contributions from each draw in a test pattern are added to obtain a value for N* for each draw pattern. For the existing DOE consumer water heater test, N* is 5.64, as the standby time

following each draw is slightly under 60 minutes. The values for N* for all draw patterns are provided in Table III.5.

Table III.5 Estimate of number of draws from which all energy from water heater is lost to surroundings

Draw Pattern	**N***
Existing Consumer Water Heater Draw Pattern	5.64
Very-Small-Use	4.36
Low-Use	6.72
Medium-Use	7.45
High-Use	7.53

DOE attempted this approach by obtaining an estimate of LF from data obtained during testing of 17 gas instantaneous water heaters according to the current simulated-use test. (LF could theoretically be determined for each unit, but some test results showed a recovery efficiency equal to EF, which would mathematically lead to an infinite value of LF). A regression of the energy consumption data during these tests with the quantity multiplying LF in the previous model equation resulted in a value of LF of 0.679 Btu/°F. Using this value to then estimate the energy consumption during the new simulated-use test resulted in predictions of the UEF. This approach resulted in a root mean squared error between predicted values and measured values of 0.027.

Alternatively, a set of regressions, based solely on test data, were examined to determine the impact of other factors as discussed in section III.C.3. The best regressions resulted in a mean squared error of 0.032.

As discussed for consumer storage water heaters in section III.C.2.c.i, DOE also considered a two-step process to convert the existing EF ratings to the UEF – first using the equations and assumptions described above to obtain an analytical prediction of UEF, then using a regression analysis to obtain a relationship that will convert from EF to UEF. Based on these results, DOE has chosen to use the analytical model plus a regression approach for converting EFs for consumer instantaneous water heaters to UEF. DOE has tentatively concluded that the assumptions made in the analytical model capture some key operating characteristics of the instantaneous units, and the further step to use measured data captures unforeseen issues. Details on this approach are provided in section III.C.3.

iii. Residential-Duty Commercial Water Heaters

DOE investigated a modified version of WHAM for converting the thermal efficiency and standby loss metrics for residential-duty commercial storage water heaters to UEF. The AHRI certification directory includes the thermal efficiency (E_t) and standby loss (SL). The equation below estimates the energy consumption of a water heater based on these efficiency metrics:

$$Q = \frac{\rho c_p V (T_{del} - T_{in})}{E_t} + 24 \cdot \frac{SL}{70} \cdot (T_{tank} - T_{amb})$$

where 70 represents the nominal temperature difference in degrees Fahrenheit between the tank and ambient during the standby loss test. By assuming that T_{tank} equals T_{del}, all variables in the equation above are known, since E_t and SL can be obtained from current ratings and all other variables are specified in the UEF test procedure for a given projected first-hour rating. The

equation above can be used in combination with the one below to estimate the UEF for residential-duty storage water heaters (UEF_{rd}):

$$UEF_{rd} = \frac{\rho c_p V (T_{del} - T_{in})}{Q}$$

These equations can be combined to yield the following equation for converting Et and SL to UEF using the coefficient C_1, which is dependent upon the draw pattern applied during the UEF test, as provided in **Table** III.6.

$$UEF = \frac{1}{1/_{E_t + C_1 SL}}$$

Table III.6. Coefficient for conversion of commercial water heater ratings to UEF

Draw Pattern	C_1
Very Small	3.575×10^{-3}
Low	9.408×10^{-4}
Medium	6.500×10^{-4}
High	4.256×10^{-4}

As was done with consumer water heaters, DOE decided to account for unforeseen effects observed during testing by combining this analytical prediction with a regression of the predicted values of UEF to the measured UEF.

DOE seeks comments on the use of analytical methods to convert existing metrics to the ones described in the July 2014 test procedure final rule. This is identified as issue 2 in section V.E, "Issues on Which DOE Seeks Comment."

3. Empirical Regression

An alternative to the analytical approaches described in section III.C.2 is to develop empirical equations from measured metrics under the uniform efficiency descriptor test procedure to those obtained using the existing consumer and commercial water heater test procedures. This approach has the benefit of capturing the effects of factors that are not addressed in analytical models. The drawbacks of this approach are that it is susceptible to measurement errors and that it may not be easily extended to water heaters that were not part of the test program.

To derive the conversion factors from an empirical regression, DOE first used a step regression method. The step regression method produces a linear equation which uses a set of observed independent variables, such as storage volume, input rate, delivery capacity, recovery efficiency, energy factor, thermal efficiency, or standby loss, and seeks to mathematically derive an equation using these variables to relate to a set of observed dependent variables, such as new delivery capacity (under the updated test method) and UEF. The step regression method systematically recombines the set of independent variables to produce an equation for each possible set. Each set's equation is compared to the others and the equation with the best fit is chosen. This approach eliminates factors that are not significant in converting existing metrics to the new metrics. DOE also considered simpler regression forms to reduce confusion in converting from old metrics to new metrics and to ensure that the regressions were applicable over the broad range of water heaters available on the market. In these circumstances, DOE examined the deviations between measured values and predicted values from the correction equations. When those deviations were comparable, DOE opted for simplified models that

would be expected to capture the major phenomena that would affect the new metrics. The regression tool found in the Analysis ToolPak of Microsoft Excel (2010) was used to calculate the equation for each set of independent variables.

As noted previously, because DOE has tentatively concluded that an empirical regression methodology would be more accurate than the analytical method described in section III.C.2 for determining first-hour rating for storage water heaters , DOE has proposed conversion factors for those metrics and product types based on the use of the empirical regression methodology. DOE seeks comment on the use of the regression method for the conversion factor analysis. This is identified as issue 3 in section V.E, "Issues on Which DOE Seeks Comment."

D. Testing Conducted for the Mathematical Conversion

1. Consumer Water Heater Testing

For its analysis of a mathematical conversion factor between the existing efficiency metrics and the uniform efficiency descriptor, DOE tested 43 consumer storage water heaters to both the existing and updated test procedures. Table III.7 and Table III.8 below summarize the units that have been tested. Table III.7 summarizes the units that have been tested according to heating type. Table III.8 provides an estimate of the distribution of those units across draw pattern categories by using their first-hour ratings under the current test (although it is acknowledged that the applied draw pattern for a particular water heater could change under the new first-hour rating test).

Table III.7 Consumer Storage Water Heater Test Distribution by Product Type

Product Type	Number of Units Tested

Gas-fired	22
Oil-fired	2
Electric	11
Heat Pump	6
Tabletop	2

Table III.8 Consumer Storage Water Heater Test Distribution by Draw Pattern

Draw Pattern*	Number of Units Tested
Very Small**	0
Low	3
Medium	27
High	13

*The draw pattern shown is based on the current rated values; actual draw patterns are dependent upon amended test procedure first-hour rating discussed in section III.C.1.
**No very small consumer storage water heaters covered under the existing test procedure were found on the market.

DOE also tested 22 consumer instantaneous water heaters to develop the mathematical conversion for these products. Table III.9 below summarizes the units that have been tested. Table III.10 provides an estimate of the distribution of those units across draw patterns by using their maximum GPM ratings under the current test (although it is acknowledged that the applied draw pattern for a particular water heater could change under the new maximum GPM test).

Table III.9 Consumer Instantaneous Water Heater Test Distribution by Product Type

Product Type	Number of Units Tested
Gas-fired*	17
Oil-fired**	0
Electric	5

*Gas-fired water heaters include both natural gas and propane water heaters, as well as water heaters capable of using either natural gas or propane. DOE tested 10 natural gas water heaters, 1 propane water heaters, and 6 water heaters capable of using either natural gas or propane. Water heaters capable of using either fuel were tested with natural gas.
**No oil-fired consumer instantaneous water heaters were found to be on the market.

Table III.10 Consumer Instantaneous Water Heater Test Distribution by Draw Pattern

Draw Pattern*	Number of Units Tested
Very Small	5
Low	1

Medium	7
High	9

*Draw pattern profiles are based on the rated values; actual draw patterns are dependent upon tested value discussed in section III.C.1.

2. Residential-Duty Commercial Water Heater Testing

DOE tested 7 residential-duty commercial storage water heaters to develop the mathematical conversion for this equipment. Table III.11 summarizes the units that have been tested. A table showing the distribution of draw pattern within the residential-duty commercial water heater test list is not available, because commercial water heaters currently do not have first-hour ratings.

Table III.11 Residential-Duty Commercial Storage Water Heater Test Distribution by Product Type

Product Type*	Number of Units Tested
Gas-fired	7
Oil-fired**	0

*Heat pump and tabletop water heaters were not found on the market and, therefore, were not tested.
**One oil-fired unit failed during testing.

As discussed in section III.B.2, DOE did not analyze a mathematical conversion for residential-duty commercial electric storage water heaters or residential-duty commercial instantaneous water heaters.

E. Testing Results and Analysis of Test Data

1. Impact of Certain Water Heater Attributes on Efficiency Ratings

After conducting testing on all of the selected water heaters according to both the existing test procedures and the uniform efficiency descriptor test procedure, DOE examined how particular attributes of water heaters might affect the conversion factors and investigated the

approaches discussed in section III.C for obtaining conversion factors. The goal of this analysis was to determine whether or not particular attributes necessitated separate conversion equations. Separate conversions were created for subsets of the tested units based on water heater attributes such as NOx emission level, short or tall configuration, vent type, standing pilot or electric ignition, if condensing or heat pump technology is used, and if the unit is tabletop. Additionally, conversion equations were also generated based on the full set of water heaters. To determine whether it was necessary to develop separate conversion factors for a particular attribute, the root-mean-square (RMS) of the difference between the measured values and the values obtained through various conversion methods was compared. The conversion approach with the lowest cumulative RMS value for a particular fuel type was considered to be the best candidate for the conversion equation.

The three levels of NO_X emissions currently available in water heaters on the market include standard (greater than or equal to 40 nanograms per joule (ng/J)), low (less than 40 ng/J and greater than or equal to 10 ng/J for storage water heaters and greater than or equal to 14 ng/J for instantaneous water heaters) and ultra-low (less than 10 ng/J for storage water heaters and less than 14 ng/J for instantaneous water heaters).

Most units that are short or tall have been labeled as such by the manufacturer; however, some units do not have this designation. DOE has found that some units labeled as small are actually taller than units labeled as tall. DOE is interested in how manufacturers determine whether a unit is short or tall. This is identified as issue 4 in section V.E, "Issues on Which DOE Seeks Comment."

The four venting configurations currently available in water heaters on the market include atmospheric, direct, power, and power-direct. Atmospheric and power vent units intake air from the area surrounding the water heater, while direct and power-direct vents intake air from outdoors. Atmospheric and direct vent units use natural convection to circulate combustion air, while power and power-direct vents use some additional method to force circulation of combustion air. Concentric inlet and outlet piping is a unique configuration that can be used in directly venting water heaters to preheat incoming air using exhaust gas. For these tests, concentric inlet and outlet piping was not used; inlet air for the direct and power-direct vent units was delivered to the water heater in separate pipes from that used for exhaust. As these tests were conducted under identical controlled conditions, DOE determined that there is very little difference between atmospheric and direct vent water heaters and also between power and power-direct vent. For these reasons DOE has grouped atmospheric and direct into the atmospheric configuration and power and power-direct into the power configuration.

As an example of the process that was taken to examine the effect of these factors, Table III.12 shows the cumulative RMS values for the first-hour rating conversions for consumer storage water heaters. The rows in the table indicate how the conversion equations were separated out, and the columns provide the RMS for each class of consumer storage water heaters. For gas water heaters, these values show that the conversion approach that differentiates between condensing or non-condensing technology and between NO_X levels appears to provide the best approach considering its low RMS values. No other factors (*e.g.*, short vs. tall, vent type, pilot type) were shown to have any significance on the effectiveness of the conversion

factor. For oil-fired water heaters and electric water heaters, the lowest RMS deviations occurred when all units of that fuel type were considered, indicating that separating the conversion equations by tank shape was not necessary. The findings presented here for first-hour rating conversions are consistent with those for UEF. From these results, DOE proposes to develop conversion equations for consumer storage water heaters based on fuel type, with the gas units being further differentiated by whether or not they are condensing units and by their NOx emissions level ratings.

For consumer instantaneous water heaters and residential-duty commercial water heaters, DOE found no dependence on factors such as condensing operation or vent type. Conversion factors for these classes of water heaters are, thus, based simply on fuel type.

Table III.12 First-Hour Rating RMS Values by Water Heater Attribute for Consumer Water Heaters

	Gas-fired	Oil-fired	Electric
All Units (All fuel types)	6.99	6.89	4.47
All Units Short or Tall	6.87	5.79	3.67
Fuel Type (Gas, Oil or Electric)	7.16	Not enough units	3.88
Fuel Type Short or Tall	6.91	No short units	Not enough short units
Fossil Fuel (Gas and Oil)	6.59	5.73	N/A
Fossil Fuel Short or Tall	6.52	5.82	N/A
Condensing or Non-Condensing	6.66	N/A	N/A
NOx Type (Standard, Low or Ultra Low)	4.61	N/A	N/A
Vent Type (Atmospheric or Power)	5.53	N/A	N/A

Standing Pilot or Electric Ignition	5.53	N/A	N/A
Non-Condensing NOx Type and Separate Condensing	3.98	N/A	N/A
All Electric Types Separate	N/A	N/A	3.43
Heat Pump Separate	N/A	N/A	3.59

2. Conversion Factor Derivation

DOE used the methods described in section III.C to derive the mathematical conversion factor for the different types of water heaters covered within the scope of this rulemaking (as discussed in section III.B). This section describes the methodology that was applied to develop a conversion factor for each type of water heater.

a. Consumer Storage Water Heaters

i. Test Results

As stated in section III.D.1, DOE has conducted testing of 43 consumer storage water heaters using both the current and new test procedures. Table III.13 below presents the test data used to derive the consumer storage water heater conversion factors. Table III.14 shows the water heater attributes by unit described in section III.D.1.

Table III.13 Consumer Storage Water Heater Test Data

Unit Number	Type	Storage Volume (gal)	Input Rate (Btu/h)	Current FHR (gal)	Updated FHR (gal)	Current Recovery Efficiency (%)	EF	UEF
CS-1	Heat Pump	45.2	13,600	59.1	48.2	264.7	2.260	2.069
CS-2	Heat Pump	45.5	8,500	57.3	57.0	269.0	2.272	2.575
CS-3	Heat Pump	58.9	6,800	71.5	68.6	290.1	2.406	2.493

CS-4	Heat Pump	77.6	6,800	90.5	87.1	285.0	2.315	2.641
CS-5	Heat Pump	80.8	1,800	57.0	58.0	288.0	2.330	2.540
CS-6	Electric	36.2	15,400	54.0	49.7	98.0	0.941	0.905
CS-7	Electric	44.9	14,300	64.1	64.3	98.0	0.855	0.840
CS-8	Electric	46.1	14,000	64.8	61.7	98.0	0.901	0.919
CS-9	Electric	27.4	13,000	38.7	43.1	98.0	0.912	0.906
CS-10	Electric	34.1	14,000	50.7	52.0	98.0	0.902	0.907
CS-11	Electric	35.9	15,400	52.4	51.8	98.0	0.931	0.920
CS-12	Electric	36.1	15,400	53.2	54.8	98.0	0.912	0.927
CS-13	Electric	44.9	15,400	64.9	59.4	98.0	0.960	0.926
CS-14	Electric	45.8	15,400	62.7	64.2	98.0	0.922	0.936
CS-15	Electric	49.7	18,800	68.5	73.2	98.0	0.924	0.940
CS-16	Electric	72.2	14,700	88.7	80.9	98.0	0.848	0.883
CS-17	Tabletop	25.7	15,400	37.5	45.3	98.0	0.905	0.857
CS-18	Tabletop	35.1	15,400	52.9	47.8	98.0	0.878	0.804
CS-19	Gas	38.4	39,800	67.0	81.1	80.5	0.601	0.630
CS-20	Gas	49.5	44,100	97.4	86.6	80.5	0.610	0.634
CS-21	Gas	37.8	39,700	70.1	86.9	83.8	0.608	0.641
CS-22	Gas	47.6	49,900	90.2	81.0	81.1	0.674	0.675
CS-23	Gas	37.9	39,400	74.4	81.6	80.3	0.691	0.705
CS-24	Gas	38.0	32,600	66.9	58.5	69.0	0.574	0.566
CS-25	Gas	38.0	39,800	80.2	63.8	83.6	0.711	0.669
CS-26	Gas	38.1	40,800	73.5	75.2	83.6	0.702	0.716
CS-27	Gas	38.2	39,300	71.9	77.6	77.4	0.607	0.635
CS-28	Gas	27.9	31,600	58.8	64.4	80.7	0.620	0.606
CS-29	Gas	38.1	40,200	74.7	70.6	80.5	0.622	0.569
CS-30	Gas	38.3	37,900	71.9	64.6	78.5	0.616	0.434
CS-31	Gas	47.3	50,600	95.1	87.0	78.8	0.606	0.640
CS-32	Gas	38.6	40,100	70.2	67.2	80.4	0.673	0.647
CS-33	Gas	38.9	32,400	68.6	65.2	78.1	0.666	0.624
CS-34	Gas	27.9	59,000	96.9	94.5	78.2	0.702	0.709
CS-35	Gas	38.5	36,000	66.0	68.0	85.0	0.699	0.670
CS-36	Gas	47.8	64,600	107.9	108.8	79.5	0.649	0.672
CS-37	Gas	45.7	39,800	91.0	84.8	96.3	0.830	0.828
CS-38	Gas	38.2	40,300	68.2	64.8	79.7	0.606	0.595
CS-39	Gas	38.2	38,300	71.3	64.6	75.2	0.625	0.596
CS-40	Gas	47.8	40,500	94.2	83.8	74.0	0.550	0.641
CS-41	Gas	48.1	36,000	92.4	88.2	81.4	0.631	0.662
CS-42	Oil	29.8	105,300	104.8	111.7	71.4	0.518	0.478
CS-43	Oil	30.1	105,300	112.5	127.4	89.4	0.605	0.641

Table III.14 Consumer Storage Water Heater Attributes

Unit Number	NOx Emission Level	Condensing	Vent Type	Short or Tall	Standing Pilot or Electric Ignition
CS-1	N/A	N/A	N/A	N/A	N/A
CS-2	N/A	N/A	N/A	N/A	N/A
CS-3	N/A	N/A	N/A	N/A	N/A
CS-4	N/A	N/A	N/A	N/A	N/A
CS-5	N/A	N/A	N/A	N/A	N/A
CS-6	N/A	N/A	N/A	Short	N/A
CS-7	N/A	N/A	N/A	Short	N/A
CS-8	N/A	N/A	N/A	Short	N/A
CS-9	N/A	N/A	N/A	Tall	N/A
CS-10	N/A	N/A	N/A	Tall	N/A
CS-11	N/A	N/A	N/A	Tall	N/A
CS-12	N/A	N/A	N/A	Tall	N/A
CS-13	N/A	N/A	N/A	Tall	N/A
CS-14	N/A	N/A	N/A	Tall	N/A
CS-15	N/A	N/A	N/A	Tall	N/A
CS-16	N/A	N/A	N/A	Tall	N/A
CS-17	N/A	N/A	N/A	N/A	N/A
CS-18	N/A	N/A	N/A	N/A	N/A
CS-19	Standard	No	Atmospheric	Short	Yes
CS-20	Standard	No	Atmospheric	Short	Yes
CS-21	Standard	No	Atmospheric	Tall	Yes
CS-22	Standard	No	Power	Tall	No
CS-23	Low	No	Atmospheric	Short	No
CS-24	Low	No	Atmospheric	Short	Yes
CS-25	Low	No	Atmospheric	Tall	No
CS-26	Low	No	Atmospheric	Tall	No
CS-27	Low	No	Atmospheric	Tall	No
CS-28	Low	No	Atmospheric	Tall	Yes
CS-29	Low	No	Atmospheric	Tall	Yes
CS-30	Low	No	Atmospheric	Tall	Yes
CS-31	Low	No	Atmospheric	Tall	Yes
CS-32	Low	No	Power	Short	No
CS-33	Low	No	Power	Short	No
CS-34	Low	No	Power	Tall	No
CS-35	Low	No	Power	Tall	No
CS-36	Low	No	Power	Tall	No

CS-37	Low	Yes	Power	Tall	No
CS-38	Ultra-Low	No	Atmospheric	Short	Yes
CS-39	Ultra-Low	No	Atmospheric	Short	Yes
CS-40	Ultra-Low	No	Atmospheric	Tall	Yes
CS-41	Ultra-Low	No	Atmospheric	Tall	Yes
CS-42	N/A	N/A	N/A	Tall	N/A
CS-43	N/A	N/A	N/A	Tall	N/A

ii. Conversion Factor Results

For consumer storage water heaters, DOE proposes to use the regression method described in section III.C.3 to develop new first hour ratings. Of the factors considered, DOE found that the existing first hour rating was the best overall predictor of the new first hour rating. These findings were based on the root mean squared errors between predictions and measured values. In some cases, addition of other factors in the regressions (e.g., input rate, storage volume) led to predictions with slightly better RMS values, but DOE chose to be consistent in its formulations by using the same factor, existing first hour ratings. In these cases, DOE found that addition of extra terms improved the RMS value by less than 1 gallon, so it tentatively concluded that the added potential for confusion is not warranted. The resulting equations for determining the FHR_{new} of consumer storage water heaters are:

$$New\ FHR_{Gas,Non-Condensing,Standard\ NOx} = 1.0085 * FHR_{Ex}$$

$$New\ FHR_{Gas,Non-Condensing,Low\ NOx} = 4.6894 + 0.9112 * FHR_{Ex}$$

$$New\ FHR_{Gas,Non-Condensing,Ultra-Low\ NOx} = 2.9267 + 0.8882 * FHR_{Ex}$$

$$New\ FHR_{Gas,Condensing} = -0.7072 + 0.9724 * FHR_{Ex}$$

$$New\ FHR_{Oil} = 1.1018 * FHR_{Ex}$$

$$New\ FHR_{Electric,Conventional\&Tabletop} = 11.9239 + 0.7879 * FHR_{Ex}$$

$$New\ FHR_{Electric,Heat\ Pump} = -2.3440 + 0.9856 * FHR_{Ex}$$

where FHR_{new} is the new first hour rating, FHR_{ex} is the existing first hour rating, and the slope and intercept are constants obtained from a linear regression. While most of the data allowed for such a regression fit, in two cases (oil, non-condensing gas with standard level NOx burners) the available data were too limited to produce reliable regressions. In these cases, the intercepts of the regressions were assigned a value of zero, meaning that a water heater with an FHR_{ex} of zero would also have an FHR_{new} of zero.

The next step in the conversion is to determine which draw pattern is to be applied to convert from EF to UEF. After the first-hour rating under the uniform efficiency descriptor is determined through the conversion factor above, the value can be applied to determine the appropriate draw pattern bin (*i.e.*, very small, low, medium, or high) using Table III.3 of this NOPR or Table 1 of the uniform efficiency descriptor test procedure. 79 FR 40542, 40572 (July 11, 2014). With the draw bin known, the UEF value based on the WHAM analytical model can be calculated using the process described in section III.C.2.c.i for all types except for heat pump water heaters. Alternatively, DOE investigated the step regression approach described in section III.C.3 to convert EF to UEF. DOE found that a third technique, a combination of these approaches in which the results of the WHAM analytical model are used as the independent variable in a standard linear regression analysis, produced the best results. Separate conversion equations were developed for the same categories as used for first-hour rating. The results of the first-hour regression, the WHAM analytical model, the step regression model, and the combined WHAM-regression model are presented below in Table III.16. The RMS errors for the classes

range from 0.0014 to 0.0495 when using a combined WHAM-regression model. For heat pump water heaters, a linear regression in which the UEF is estimated solely from the existing EF results in an RMS error of 0.187. Considering the larger magnitude of UEFs for heat pump water heaters, DOE has tentatively concluded that this relatively high RMS error is acceptable for heat pump water heaters. DOE has, therefore, tentatively decided to use the combined WHAM-regression approach to calculate the consumer storage water heater conversion factor for non-heat pump water heaters and to apply a regression that relates UEF to EF for heat pump water heaters. The WHAM-regression approach accounts for the test procedure changes in terms of daily volume delivered and storage tank temperature, and it corrects for the unaccounted changes using a regression with actual test data. Because the data are not believed to be publicly available to compute the WHAM estimate for heat pump water heaters, DOE proposes to base this conversion on an empirical regression. The resulting equations for determining the UEF of consumer storage water heaters are:

$$\mathrm{UEF_{WHAM}} = \left[\frac{1}{\eta_r} + \left(\frac{1}{\mathrm{EF}} - \frac{1}{\eta_r}\right)\left(\frac{\mathrm{a\ P\ \eta_r - b}}{\mathrm{c\ P\ \eta_r - d}}\right)\right]^{-1}$$

$$UEF_{Gas,Non-Condensing,Standard\ NOx} = 0.2726 * UEF_{WHAM} + 0.4736$$

$$UEF_{Gas,Non-Condensing,Low\ NOx} = 0.9966 * UEF_{WHAM} - 0.0126$$

$$UEF_{Gas,Non-Condensing,Ultra-Low\ NOx} = 0.5811 * UEF_{WHAM} + 0.2673$$

$$UEF_{Gas,Condensing} = 0.9164 * UEF_{WHAM} + 0.0409$$

$$UEF_{Oil} = 1.1185 * UEF_{WHAM} - 0.0945$$

$$UEF_{Electric,Conventional\&Tabletop} = 0.8673 * UEF_{WHAM} + 0.1227$$

$$UEF_{Electric,Heat\ Pump} = 1.5485 * EF - 1.1235$$

where UEF_{WHAM} is the conversion factor calculated using the WHAM analytical model and the coefficient values shown in Table III.15, P is the nameplate input rate in Btu/h, and η_r is the recovery efficiency expressed in decimal form (*e.g.*, 0.98 instead of 98 [%]).

Table III.15 Coefficients for WHAM-based UEF Conversion Factor

Draw Bin	a	b	c	d
Very Small	56095146	12884892499	8930623	15125743368
Low	56095146	48962591496	33936368	57477824799
Medium	56095146	70866908744	49118427	83191588525
High	56095146	108233096990	75017235	127056244293

Table III.16 Consumer Storage Water Heater Conversion Factor Results

Unit Number	Tested FHR (gal)	Regression FHR (gal)	Tested UEF	WHAM UEF	Regression UEF	WHAM-Regression UEF
CS-1	48.2	55.9	2.069	2.209	2.375	2.384
CS-2	57.0	54.1	2.575	2.215	2.395	2.391
CS-3	68.6	68.1	2.493	2.339	2.603	2.525
CS-4	87.1	86.9	2.641	2.435	2.461	2.630
CS-5	58.0	53.8	2.540	2.213	2.484	2.388
CS-6	49.7	54.4	0.905	0.935	0.930	0.933
CS-7	64.3	62.4	0.840	0.836	0.875	0.847
CS-8	61.7	62.9	0.919	0.888	0.904	0.893
CS-9	43.1	42.4	0.906	0.866	0.911	0.874
CS-10	52.0	51.8	0.907	0.888	0.905	0.893
CS-11	51.8	53.2	0.920	0.923	0.923	0.923
CS-12	54.8	53.9	0.927	0.901	0.911	0.904
CS-13	59.4	63.0	0.926	0.956	0.941	0.952
CS-14	64.2	61.4	0.936	0.912	0.917	0.914
CS-15	73.2	65.9	0.940	0.915	0.919	0.916
CS-16	80.9	81.8	0.883	0.880	0.871	0.885
CS-17	45.3	41.5	0.857	0.855	0.896	0.864
CS-18	47.8	53.6	0.804	0.862	0.873	0.870
CS-19	81.1	67.5	0.630	0.578	0.632	0.631
CS-20	86.6	98.3	0.634	0.651	0.637	0.651
CS-21	86.9	70.7	0.641	0.583	0.636	0.632
CS-22	81.0	91.0	0.675	0.705	0.675	0.666
CS-23	81.6	72.5	0.705	0.676	0.683	0.661

CS-24	58.5	65.6	0.566	0.558	0.571	0.544
CS-25	63.8	77.8	0.669	0.739	0.702	0.724
CS-26	75.2	71.6	0.716	0.685	0.694	0.670
CS-27	77.6	70.2	0.635	0.587	0.603	0.572
CS-28	64.4	58.3	0.606	0.598	0.616	0.583
CS-29	70.6	72.8	0.569	0.600	0.617	0.585
CS-30	64.6	70.2	0.434	0.595	0.611	0.580
CS-31	87.0	91.4	0.640	0.645	0.602	0.630
CS-32	67.2	68.6	0.647	0.656	0.666	0.641
CS-33	65.2	67.2	0.624	0.651	0.660	0.636
CS-34	94.5	93.0	0.709	0.721	0.694	0.706
CS-35	68.0	64.8	0.670	0.679	0.690	0.664
CS-36	108.8	103.0	0.672	0.681	0.643	0.666
CS-37	84.8	87.8	0.828	0.861	0.824	0.830
CS-38	64.8	63.5	0.595	0.583	0.592	0.606
CS-39	64.6	66.3	0.596	0.609	0.599	0.621
CS-40	83.8	86.6	0.641	0.589	0.653	0.610
CS-41	88.2	85.0	0.662	0.670	0.649	0.656
CS-42	111.7	115.5	0.478	0.557	0.537	0.529
CS-43	127.4	123.9	0.641	0.659	0.613	0.643

b. Consumer Instantaneous

i. Test Results

As stated in section III.D.1, DOE has tested 22 consumer instantaneous water heaters to both the current and new test procedures. Table III.17 presents the test data used to derive the consumer instantaneous water heater conversion factors. It is noted that test results show measured recovery efficiencies above 100 percent and EFs and UEFs above 1 for electric instantaneous units; DOE acknowledges that these results appear to violate theoretical limits and believes that these results are an artifact of measurement uncertainty. Table III.18 shows the water heater attributes by unit described in section III.D.1.

Table III.17 Consumer Instantaneous Water Heater Test Data

Unit Number	Type	Input Rate (Btu/h)	Current Max GPM	Updated Max GPM	Current Recovery Efficiency (%)	EF	UEF
CI-1	Electric	8,200	0.20	0.23	101.2	1.012	0.982
CI-2	Electric	32,400	0.82	0.93	101.5	1.017	0.981
CI-3	Electric	34,100	0.87	0.99	101.8	1.018	1.001
CI-4	Electric	27,300	0.68	0.80	102.0	1.019	1.004
CI-5	Electric	20,500	0.52	0.59	102.3	1.021	1.005
CI-6	Gas	179,900	4.01	4.58	82.4	0.821	0.832
CI-7	Gas	178,500	4.08	4.71	83.8	0.837	0.828
CI-8	Gas	120,900	2.69	3.07	84.1	0.839	0.814
CI-9	Gas	199,000	4.61	4.86	87.0	0.876	0.841
CI-10	Gas	151,900	3.47	3.96	88.3	0.891	0.815
CI-11	Gas	141,100	3.11	3.61	81.4	0.810	0.824
CI-12	Gas	190,400	4.23	4.81	83.4	0.829	0.818
CI-13	Gas	142,500	2.96	3.43	80.9	0.801	0.795
CI-14	Gas	197,200	5.19	5.80	96.7	0.966	0.958
CI-15	Gas	199,800	4.80	4.10	93.8	0.932	0.931
CI-16	Gas	151,500	3.24	3.88	84.3	0.837	0.805
CI-17	Gas	180,400	3.92	4.60	85.0	0.853	0.827
CI-18	Gas	175,800	3.67	4.30	84.5	0.838	0.830
CI-19	Gas	199,200	4.30	5.07	75.0	0.743	0.799
CI-20	Gas	154,100	3.98	4.47	91.6	0.913	0.922
CI-21	Gas	201,300	4.90	5.70	88.0	0.851	0.884
CI-22	Gas	199,900	5.12	4.91	89.9	0.888	0.943

Table III.18 Consumer Instantaneous Water Heater Attributes

Unit Number	NOx Emission Level	Condensing	Vent Type
CI-1	N/A	N/A	N/A
CI-2	N/A	N/A	N/A
CI-3	N/A	N/A	N/A
CI-4	N/A	N/A	N/A
CI-5	N/A	N/A	N/A
CI-6	Low	No	Atmospheric
CI-7	Low	No	Atmospheric
CI-8	Low	No	Atmospheric
CI-9	Low	No	Atmospheric
CI-10	Low	No	Atmospheric

CI-11	Low	No	Power
CI-12	Low	No	Power
CI-13	Low	No	Power
CI-14	Low	Yes	Atmospheric
CI-15	Low	Yes	Atmospheric
CI-16	Ultra-Low	No	Atmospheric
CI-17	Ultra-Low	No	Atmospheric
CI-18	Ultra-Low	No	Atmospheric
CI-19	Ultra-Low	No	Atmospheric
CI-20	Ultra-Low	Yes	Atmospheric
CI-21	Ultra-Low	Yes	Atmospheric
CI-22	Ultra-Low	Yes	Power

ii. Conversion Factor Results

As stated in section III.C.2, DOE developed an analytical model to convert the existing maximum GPM rating for consumer instantaneous water heaters to ratings under the uniform efficiency descriptor test procedure. DOE also attempted to develop an analytical method based on the WHAM equation to estimate the change in existing energy factor ratings under the existing consumer water heater test procedure to values under the uniform efficiency descriptor test procedure. Along with this analytical model, step regression and combined analytical model-regression approaches were conducted. The results of the analytical model, step regression, and combined analytical model-regression approaches for the maximum GPM and UEF conversions are presented in Table III.20. For the maximum GPM conversions, the RMS errors for the three approaches are 0.38, 0.35, and 0.38, respectively. For the UEF conversions, the three approaches have RMS errors of 0.024, 0.028, and 0.023, respectively. DOE has tentatively decided to use the analytical model approach to calculate the consumer instantaneous maximum GPM conversion factor owing to the fact that the model predicts the resultant data very closely and that it will broadly apply to those units not tested. DOE has also tentatively decided to use the combined analytical model-regression approach to convert from EF to UEF

since the RMS errors are low, and it has tentatively concluded that the use of the model and regression will capture key effects that may not be captured with either approach by itself. For the electric instantaneous water heaters, DOE imposed a zero intercept on the regression since the regression with an intercept resulted in UEFs above the theoretical limit of 1. DOE has tentatively concluded that this step is technically acceptable, as it effectively states that a water heater with an EF of zero should also have a UEF of zero. The resulting conversion factors for both first hour rating and UEF are:

$$MaxGPM_{new} = 1.147 * MaxGPM_{Ex}$$

$$UEF_{gas} = 0.9059 * UEF_{model} + 0.0783$$

$$UEF_{electric} = 1.0079 * UEF_{model}$$

where $MaxGPM_{Ex}$ is the maximum GPM rating based on the current DOE test procedure and UEF_{model} is the predicted UEF determined using the following analytical model:

$$UEF_{model} = \frac{A}{A/\eta_r + B}$$

Values for the coefficients A and B are dependent upon the draw pattern applied during the simulated-use test and are provided in Table **III.19**.

Table III.19 Coefficients to Determine UEF_{model} for Consumer Instantaneous Water Heaters

Draw Bin	A	B
Very Small	5514.2	170.2
Low	20954	262.4

Medium	30328	290.9
High	46319	294.0

Table III.20 Consumer Instantaneous Water Heater Conversion Factor Results

Unit Number	Tested Max GPM	Analytical Max GPM	Regression Max GPM	Combined Analytical-Regression Max GPM	Tested UEF	Analytical UEF	Regression UEF	Analytical-Regression UEF
CI-1	0.23	0.23	0.24	0.23	0.982	0.982	0.980	0.989
CI-2	0.93	0.94	0.94	0.94	0.981	0.984	0.987	0.992
CI-3	0.99	1.00	1.00	1.00	1.001	0.987	0.995	0.995
CI-4	0.80	0.78	0.78	0.78	1.004	0.989	1.001	0.997
CI-5	0.59	0.59	0.60	0.59	1.005	0.991	1.008	0.999
CI-6	4.58	4.60	4.58	4.60	0.832	0.820	0.816	0.820
CI-7	4.71	4.68	4.66	4.68	0.828	0.834	0.829	0.833
CI-8	3.07	3.08	3.17	3.08	0.814	0.834	0.830	0.834
CI-9	4.86	5.28	5.22	5.28	0.841	0.865	0.859	0.861
CI-10	3.96	3.98	4.01	3.98	0.815	0.878	0.871	0.873
CI-11	3.61	3.56	3.62	3.56	0.824	0.808	0.807	0.810
CI-12	4.81	4.85	4.82	4.85	0.818	0.829	0.822	0.829
CI-13	3.43	3.39	3.46	3.39	0.795	0.803	0.800	0.805
CI-14	5.80	5.95	5.84	5.95	0.958	0.961	0.931	0.948
CI-15	4.10	5.50	5.43	5.50	0.931	0.933	0.904	0.923
CI-16	3.88	3.71	3.76	3.71	0.805	0.836	0.829	0.835
CI-17	4.60	4.49	4.49	4.49	0.827	0.845	0.841	0.844
CI-18	4.30	4.21	4.22	4.21	0.830	0.840	0.829	0.839
CI-19	5.07	4.93	4.90	4.93	0.799	0.746	0.754	0.754
CI-20	4.47	4.56	4.55	4.56	0.922	0.911	0.889	0.903
CI-21	5.70	5.62	5.54	5.62	0.884	0.875	0.840	0.870
CI-22	4.91	5.87	5.77	5.87	0.943	0.894	0.869	0.887

c. Residential-Duty Commercial Storage Testing

i. Test Data

As stated in section III.D.2, DOE has tested 7 residential-duty commercial storage water heaters to both the current and new test procedures. Table III.21 below presents the test data

used to derive the residential-duty commercial storage water heater conversion factors. Table III.22 shows the water heater attributes by unit described in section III.D.2.

Table III.21 Residential-Duty Commercial Storage Water Heater Test Data

Unit Number	Type	Storage Volume (gal)	Input Rate (Btu/h)	Tested Thermal Efficiency (%)	Tested Standby Loss (Btu/h)	Updated FHR (gal)	UEF
RD-1	Gas	95.4	79,100	80.4	1178.2	109.8	0.514
RD-2	Gas	72.7	67,400	67.9	721.0	90.3	0.585
RD-3	Gas	71.3	69,700	75.5	839.4	119.3	0.619
RD-4	Gas	48.3	76,500	93.6	328.0	137.0	0.816
RD-5	Gas	48.4	75,300	88.9	338.1	126.5	0.725
RD-6	Gas	47.8	75,700	90.0	358.4	103.3	0.621
RD-7	Gas	71.0	63,800	67.1	1546.8	111.5	0.470

Table III.22 Residential-Duty Commercial Storage Water Heater Attributes

Unit Number	NOx Emission Level	Condensing	Vent Type	Short or Tall	Standing Pilot or Electric Ignition
RD-1	Standard	No	Atmospheric	Tall	Yes
RD-2	Standard	No	Power	Tall	No
RD-3	Standard	No	Power	Tall	No
RD-4	Low	Yes	Atmospheric	Short	No
RD-5	Low	Yes	Power	Tall	No
RD-6	Low	Yes	Power	Tall	No
RD-7	Ultra-Low	No	Atmospheric	Tall	Yes

ii. Conversion Factor Results

As stated in section III.C.2.b, DOE is not aware of an analytical model to convert the thermal efficiency and standby loss ratings under the current test procedure to first-hour rating values under the new test procedure. Therefore, the step regression method described in section

III.C.3 along with the best combination of water heater attributes were used to determine the following first-hour rating conversion factors:

$$New\ FHR_{Fossil\ Fuel} = 1.0226 * Q + 39.81$$

where Q is the input rate of the burner in kBtu/h. For this regression, DOE decided to group both oil and gas water heaters because of the lack of oil water heaters identified. DOE has tentatively concluded that this grouping is the best approach to convert ratings for any residential-duty oil water heater on the market.

The next step in the conversion is to determine which draw pattern is to be applied to convert to UEF. After the first-hour rating under the uniform efficiency descriptor is determined through the conversion factor above, the value can be applied to determine the appropriate draw pattern bin (*i.e.*, very small, low, medium, or high) using Table III.3 of this NOPR or Table 1 of the uniform efficiency descriptor test procedure. 79 FR 40542, 40572 (July 11, 2014). With the draw bin known, the UEF value based on the analytical model can be calculated using the process described in section III.C.2.c.iii. The analytical results, along with the results of the step regression and analytical-regression are shown in Table III.23 and have RMS values of 0.074, 0.055, and 0.053, respectively. Based on these results, DOE has tentatively decided to use the combined analytical-regression approach to calculate the residential-duty commercial storage water heater conversion factor. While the regression approach yields a slightly better RMS error, DOE has tentatively concluded that the use of the analytical model will make the conversion more robust over the entire family of residential-duty commercial storage water heaters since it captures the effects of water temperature, draw volume per day, thermal efficiency, and standby

loss that are expected to be valid for any water heater. Thus, the use of an analytical model is expected to be less prone to error should a model have some unexpected characteristic that was not captured in the water heaters tested as part of this NOPR. The resulting equations for determining the UEF of consumer storage water heaters are:

$$UEF_{fossil\ fuel} = 0.7300 * UEF_{rd} + 0.1413$$

where UEF_{rd} is the estimate of the UEF for residential-duty water heaters computed with the following equation:

$$UEF_{rd} = \frac{1}{1/_{E_t + C_1 SL}}$$

where C_1 is a constant dependent upon the draw pattern given in Table III.6, E_t is the thermal efficiency in fractional form (*i.e.*, 0.85 instead of 85 (%)), and SL is the standby loss in BTU/h.

Table III.23 Residential-Duty Commercial Conversion Factor Results

Unit Number	Tested FHR (gal)	Regression FHR (gal)	Tested UEF	Analytical UEF	Regression UEF	Analytical-Regression UEF
RD-1	109.8	120.7	0.514	0.573	0.530	0.560
RD-2	90.3	108.8	0.585	0.562	0.629	0.551
RD-3	119.3	111.1	0.619	0.595	0.604	0.575
RD-4	137.0	118.0	0.816	0.828	0.715	0.746
RD-5	126.5	116.9	0.725	0.788	0.713	0.717
RD-6	103.3	117.3	0.621	0.791	0.709	0.719
RD-7	111.5	105.0	0.470	0.466	0.449	0.481

d. Residential-Duty Instantaneous Testing

As discussed in section III.B.2, no instantaneous residential-duty commercial water heaters exist on the market. Therefore, a conversion factor is not needed.

3. Energy Conservation Standard Derivation

After developing the mathematical conversion factors to convert from the existing efficiency ratings to the efficiency ratings under the UEF metric, DOE sought to update its energy conservation standards for covered water heater products so as to be in terms of UEF. DOE investigated several possible methods to determine the appropriate energy conservation standards in terms of UEF.

First, DOE considered the "percent difference" method, which is the method DOE ultimately has proposed for updating the energy conservation standards so as to be based on the UEF metric. The percent difference method was conducted as follows:

1. Apply conversion factor to convert the current efficiency metrics provided in the relevant consumer or commercial database to the calculated UEF value for each water heater on the market.
2. Calculate the current efficiency standard for each water heater in the database, as follows:
    a. For consumer water heaters, find the minimum EF.
    b. For residential-duty commercial water heaters, find the minimum thermal efficiency.

3. Find the percent difference between the rated efficiency value and the standard for each water heater in the database, as follows:
    a. For consumer water heaters, $Percent\ Difference = \frac{E_f - E_{f,min}}{E_f} = PD$
    b. For residential-duty commercial water heaters, $PD = \left(\frac{TE - TE_{min}}{TE}\right)/2$
4. Find the new energy conservation standard for each water heater in the database, as follows:
    a. $UEF_{min} = UEF(1 - PD)$
5. Find a line through their minimum UEF values.

The advantage of using a "percent difference" is that the updated energy conservation standard is a function of the UEF conversion for all water heaters rather than a subset. It also allows for conversions of standards for classes or groupings of water heaters where no minimally compliant models are currently available on the market. The proposed standards in terms of uniform energy factor are shown below by product class and draw pattern.

Table III.24 Updated Consumer Water Heater Energy Conservation Standards

Product Class	Rated Storage Volume	Draw Pattern	Uniform Energy Factor
Gas-fired Storage	≥ 20 gal and ≤ 55 gal	Very Small	$0.3263 - (0.0019\ x\ V_r)$
		Low	$0.5891 - (0.0019\ x\ V_r)$
		Medium	$0.6326 - (0.0013\ x\ V_r)$
		High	$0.7128 - (0.0025\ x\ V_r)$
	> 55 gal and ≤ 100 gal	Very Small	$0.5352 - (0.0007\ x\ V_r)$
		Low	$0.7375 - (0.0009\ x\ V_r)$
		Medium	$0.7704 - (0.0010\ x\ V_r)$
		High	$0.7980 - (0.0010\ x\ V_r)$
Oil-fired Storage	≤ 50 gal	Very Small	$0.2267 - (0.0014\ x\ V_r)$
		Low	$0.4867 - (0.0006\ x\ V_r)$
		Medium	$0.6016 - (0.0012\ x\ V_r)$

		High	$0.6529 - (0.0005\ x\ V_r)$
Electric Storage	≥ 20 gal and ≤ 55 gal	Very Small	$0.8268 - (0.0002\ x\ V_r)$
		Low	$0.9393 - (0.0004\ x\ V_r)$
		Medium	$0.9683 - (0.0007\ x\ V_r)$
		High	$0.9656 - (0.0004\ x\ V_r)$
	> 55 gal and ≤ 120 gal	Very Small	$1.2701 - (0.0011\ x\ V_r)$
		Low	$1.9137 - (0.0011\ x\ V_r)$
		Medium	$2.0626 - (0.0011\ x\ V_r)$
		High	$2.1858 - (0.0011\ x\ V_r)$
Tabletop Storage	≥ 20 gal and ≤ 100 gal	Very Small	$0.6808 - (0.0022\ x\ V_r)$
		Low	$0.8770 - (0.0012\ x\ V_r)$
		Medium	$0.9063 - (0.0009\ x\ V_r)$
		High	$0.9302 - (0.0006\ x\ V_r)$
Gas-fired Instantaneous	< 2 gal	All	$0.8036 - (0.0019\ x\ V_r)$
Electric Instantaneous	< 2 gal	All	$0.9192 - (0.0013\ x\ V_r)$

*V_r is the rated storage volume which equals the water storage capacity of a water heater (in gallons), as specified by the manufacturer.

Table III.25 Updated Residential-Duty Commercial Water Heater Energy Conservation Standards

Product Class	Draw Pattern	Uniform Energy Factor
Gas-fired Storage	Very Small	$0.3261 - (0.0006\ x\ V_r)$
	Low	$0.5219 - (0.0008\ x\ V_r)$
	Medium	$0.5585 - (0.0006\ x\ V_r)$
	High	$0.6044 - (0.0005\ x\ V_r)$
Oil-fired Storage	Very Small	$0.3206 - (0.0006\ x\ V_r)$
	Low	$0.5577 - (0.0019\ x\ V_r)$
	Medium	$0.6027 - (0.0019\ x\ V_r)$
	High	$0.6446 - (0.0018\ x\ V_r)$

*V_r is the rated storage volume which equals the water storage capacity of a water heater (in gallons), as specified by the manufacturer.

As stated in section III.A, EEI commented in response to the November 2013 NOPR, that the updated energy conservation standards should be not more stringent than they are currently. The percent difference from the current rated energy factors and energy conservation standards are used to derive the new energy conservation standards; therefore, the updated standards are no more stringent than those currently in existence. A.O. Smith and AHRI suggested that the

average difference between the current and new ratings should not be used to convert the energy conservation standards. At no point in the conversion factor derivation or energy conservation standard analysis is a simple average taken, but rather, the trends of all the traditional factors affecting water heaters are considered.

DOE also investigated a second method of determining the energy conservation standards where only test data from minimally-compliant water heaters would be used to develop a conversion factor using the analytical and regression methods described in section III.C. Then, this set of conversion factors could be applied to the minimum energy conservation standards to determine the appropriate energy conservation standards in terms of the UEF metric. This method would remove from consideration any factors that are present in more-efficient water heaters, so the resulting change in the standard would not be skewed at all by the inclusion of higher-efficiency products in the mathematical conversion. However, the conversion factors developed through such a methodology would potentially not be applicable for converting the efficiency ratings of products above the baseline. Therefore, DOE chose to pursue a methodology that was applicable to all water heaters and perform the conversion of standards based on the "percent difference" method described above.

DOE seeks comment on the most appropriate method for determining the energy conservation standards based on the updated test procedure. This is identified as issue 5 in section V.E, "Issues on Which DOE Seeks Comment."

F. Certification and Labeling Issues

Consumer water heaters and residential-duty commercial water heaters manufactured prior to the effective date of the uniform energy factor test procedure final rule (*i.e.*, July 13, 2015) that comply with the efficiency standards and labeling requirements in effect prior to that final rule will be considered to comply with the converted UEF standards and with any revised labeling requirements established by the Federal Trade Commission (FTC) to carry out the final rule. (42 U.S.C. 6295(e)(5)(K)) The statute requires that the standard be in terms of UEF as of July 13, 2015. Accordingly, DOE proposes to require manufacturers to provide EF and UEF for consumer water heaters (or thermal efficiency and standby loss and UEF for commercial residential-duty water heaters) in certification reports filed between July 13, 2015, and the compliance date determined by the final rule in this rulemaking. Manufacturers would not be required to submit revised certification reports for previously certified basic models until the next annual certification date (May 1).

Allowing manufacturers to submit both EF and UEF data would allow manufacturers to fulfill the statutory requirement to begin using UEF for purposes of compliance with standards but would also allow manufacturers to provide the necessary information to determine costs under the current FTC labeling requirements. This would also allow a transition period for FTC to pursue a rulemaking to determine whether changes are needed to the water heater EnergyGuide label due to changes in the water heater test procedure. DOE expects that the conversion factors proposed in this notice could be used to convert EF to UEF for previously certified basic models or to convert UEF values “backwards” to EF to determine the appropriate costs for labeling of new basic models until FTC has determined whether to make changes to the

label. DOE has proposed a methodology for calculating costs based on UEF testing that could be used in future FTC labeling requirements. DOE requests comment on whether DOE should adopt such a provision in the final rule in this rulemaking or postpone adoption until FTC has had an opportunity to evaluate the ENERGY GUIDE label.

IV. Procedural Issues and Regulatory Review

A. Review Under Executive Order 12866

The Office of Management and Budget (OMB) has determined that test procedure rulemakings do not constitute "significant regulatory actions" under section 3(f) of Executive Order 12866, Regulatory Planning and Review, 58 FR 51735 (Oct. 4, 1993). Accordingly, this action was not subject to review under the Executive Order by the Office of Information and Regulatory Affairs (OIRA) in the Office of Management and Budget.

B. Review Under the Regulatory Flexibility Act

The Regulatory Flexibility Act (5 U.S.C. 601 et seq.) requires preparation of an initial regulatory flexibility analysis (IFRA) for any rule that by law must be proposed for public comment, unless the agency certifies that the rule, if promulgated, will not have a significant economic impact on a substantial number of small entities. As required by Executive Order 13272, "Proper Consideration of Small Entities in Agency Rulemaking," 67 FR 53461 (August 16, 2002), DOE published procedures and policies on February 19, 2003, to ensure that the potential impacts of its rules on small entities are properly considered during the DOE rulemaking process. 68 FR 7990. DOE has made its procedures and policies available on the Office of the General Counsel's website: http://energy.gov/gc/office-general-counsel.

This proposed rule would prescribe a mathematical conversion that would be used to determine compliance with energy conservation standards for consumer water heaters and certain commercial water heaters. For consumer water heaters and certain commercial water heaters, the mathematical conversion would establish a bridge between the rated values based on the results under the current test procedures and the uniform efficiency descriptor of the new test procedure. Furthermore, the conversion factor will ensure that no products which currently pass energy conservation standards fail to meet the energy conservation standards after the conversion factor has been applied. DOE reviewed this proposed rule under the provisions of the Regulatory Flexibility Act and the policies and procedures published on February 19, 2003. 68 FR 7990.

For the manufacturers of the covered water heater products, the Small Business Administration (SBA) has set a size threshold, which defines those entities classified as "small businesses" for the purposes of the statute. DOE used the SBA's small business size standards to determine whether any small entities would be subject to the requirements of the rule. 65 FR 30836, 30849 (May 15, 2000), as amended at 65 FR 53533, 53545 (Sept. 5, 2000) and at 77 FR 49991, 50008-11 (August 20, 2012) and codified at 13 CFR part 121. The size standards are listed by North American Industry Classification System (NAICS) code and industry description and are available at *http://www.sba.gov/content/table-small-business-size-standards.* Consumer water heater manufacturing is classified under NAICS code 335228—"Other Major Household Appliance Manufacturing." The SBA sets a threshold of 500 employees or less for an entity to be considered as a small business. Commercial water heater manufacturing is classified under

NAICS code 333318 –"Other Commercial and Service Industry Machinery Manufacturing," for which SBA sets a size threshold of 1,000 employees or fewer as being considered a small business.

DOE has identified 19 manufacturers of consumer water heaters (including manufacturers of products that fall under the expanded scope) that can be considered small businesses. DOE identified seven manufacturers of "residential-duty" commercial water heaters that can be considered small businesses. Six of the "residential-duty" commercial water heater manufacturers also manufacture consumer water heaters, so the total number of water heater manufacturers impacted by this rule would be 20. DOE's research involved reviewing several industry trade association membership directories (e.g., AHRI), product databases (e.g., AHRI, CEC, and ENERGY STAR databases), individual company Web sites, and marketing research tools (e.g., Hoovers reports) to create a list of all domestic small business manufacturers of products covered by this rulemaking.

For the reasons explained below, DOE has concluded that the test procedure amendments contained in this proposed rule would not have a significant economic impact on any manufacturer, including small manufacturers.

For consumer water heaters that were covered under the old test procedure and energy conservation standards, the conversion factor in this proposed rule would convert the rated values based on the current test procedure to equivalent values based on the new uniform descriptor test procedure. Although the energy conservation standards for consumer water

heaters will be denominated using the uniform descriptor, the statute provides that all units that are on the market as of July 13, 2015, that meet the April 16, 2015 energy factor standard will be deemed to meet the converted standards.

For certain commercial water heaters, defined under the term "residential-duty commercial water heater," the conversion factor in this proposed rule would convert the rated values based on the current test procedure to the uniform descriptor which is based on the new test procedure. The energy conservation standards for commercial water heating equipment will be denominated using the uniform descriptor. The statute provides that all units that are on the market as of July 13, 2015, that meet the thermal efficiency and standby losses standards will be deemed to meet the converted standards.

At the date that compliance is required with the new test procedure, all water heating units with residential applications (*i.e.*, consumer units and residential-duty commercial units) must meet the applicable energy conservation standards. These units will be re-rated to the uniform descriptor based on the new test procedure. This conversion will not result in any increase in stringency of the energy conservation standards. Therefore, no units that are on the market at the time of this rulemaking will be made illegal (noncompliant) by this action.

Accordingly, DOE concludes and certifies that this final rule would not have a significant economic impact on a substantial number of small entities, so DOE has not prepared a regulatory flexibility analysis for this rulemaking. DOE will provide its certification and supporting

statement of factual basis to the Chief Counsel for Advocacy of the SBA for review under 5 U.S.C. 605(b).

C. Review Under the Paperwork Reduction Act of 1995

Manufacturers of water heaters must certify to DOE that their products comply with any applicable energy conservation standards. In certifying compliance, manufacturers must test their products according to the DOE test procedures for water heaters, including any amendments adopted for those test procedures. DOE has established regulations for the certification and recordkeeping requirements for all covered consumer products and commercial equipment, including consumer and commercial water heaters. 76 FR 12422 (March 7, 2011); 79 FR 25486 (May 5, 2014). 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

In this proposed rule, DOE proposes conversion factors to convert results from existing efficiency and delivery capacity metrics (and related energy conservation standard requirements) for consumer and certain commercial water heaters to the uniform energy descriptor. DOE has determined that this rule falls into a class of actions that are categorically excluded from review under the National Environmental Policy Act of 1969 (42 U.S.C. 4321 et seq.) and DOE's implementing regulations at 10 CFR part 1021. Specifically, this proposed rule would amend the existing rule without affecting the amount, quality or distribution of energy usage, and, therefore, would not result in any environmental impacts. Thus, this rulemaking is covered by Categorical Exclusion A5 under 10 CFR part 1021, subpart D, which applies to any rulemaking that interprets or amends an existing rule without changing the environmental effect of that rule. Accordingly, neither an environmental assessment nor an environmental impact statement is required.

E. Review Under Executive Order 13132

Executive Order 13132, "Federalism," 64 FR 43255 (August 10, 1999) imposes certain requirements on agencies formulating and implementing policies or regulations that preempt State law or that have Federalism implications. The Executive Order requires agencies to examine the constitutional and statutory authority supporting any action that would limit the policymaking discretion of the States and to carefully assess the necessity for such actions. The Executive Order also requires agencies to have an accountable process to ensure meaningful and timely input by State and local officials in the development of regulatory policies that have Federalism implications. On March 14, 2000, DOE published a statement of policy describing

the intergovernmental consultation process it will follow in the development of such regulations. 65 FR 13735. DOE has examined this proposed rule and has determined that it would not have a substantial direct effect on the States, on the relationship between the national government and the States, or on the distribution of power and responsibilities among the various levels of government. EPCA governs and prescribes Federal preemption of State regulations as to energy conservation for the products that are the subject of this proposed rule. States can petition DOE for exemption from such preemption to the extent, and based on criteria, set forth in EPCA. (42 U.S.C. 6297(d)) No further action is required by Executive Order 13132.

F. Review Under Executive Order 12988

Regarding the review of existing regulations and the promulgation of new regulations, section 3(a) of Executive Order 12988, "Civil Justice Reform," 61 FR 4729 (Feb. 7, 1996), 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. 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 sections 3(a) and 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, the proposed rule meets the relevant standards of Executive Order 12988.

G. Review Under the Unfunded Mandates Reform Act of 1995

Title II of the Unfunded Mandates Reform Act of 1995 (UMRA) requires each Federal agency to assess the effects of Federal regulatory actions on State, local, and Tribal governments and the private sector. Pub. L. No. 104-4, sec. 201 (codified at 2 U.S.C. 1531). For a proposed regulatory action likely to result in a rule that may cause the expenditure by State, local, and Tribal governments, in the aggregate, or by the private sector of $100 million or more in any one year (adjusted annually for inflation), section 202 of UMRA requires a Federal agency to publish a written statement that estimates the resulting costs, benefits, and other effects on the national economy. (2 U.S.C. 1532(a), (b)) The UMRA also requires a Federal agency to develop an effective process to permit timely input by elected officers of State, local, and Tribal governments on a proposed "significant intergovernmental mandate," and requires an agency plan for giving notice and opportunity for timely input to potentially affected small governments before establishing any requirements that might significantly or uniquely affect them. On March 18, 1997, DOE published a statement of policy on its process for intergovernmental consultation under UMRA. 62 FR 12820. (This policy is also available at http://energy.gov/gc/office-general-counsel.) DOE examined this proposed rule according to UMRA and its statement of policy and determined that the rule contains neither an intergovernmental mandate, nor a mandate that may result in the expenditure by State, local, and Tribal governments, in the

aggregate, or by the private sector, of $100 million or more in any year. Accordingly, no further assessment or analysis is required under UMRA.

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 regulation would not result in any takings that might require compensation under the Fifth Amendment to the U.S. Constitution.

J. Review Under 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 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

proposed 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 proposed significant energy action. A "significant energy action" is defined as any action by an agency that promulgates or is expected to lead to promulgation of a final rule, and that: (1) is a significant regulatory action under Executive Order 12866, or any successor order; and (2) is likely to have a significant adverse effect on the supply, distribution, or use of energy; or (3) is designated by the Administrator of OIRA as a significant energy action. For any proposed significant energy action, the agency must give a detailed statement of any adverse effects on energy supply, distribution, or use should the proposal be implemented, and of reasonable alternatives to the action and their expected benefits on energy supply, distribution, and use.

This regulatory action, which would develop a conversion factor to amend the energy conservation standards for consumer and certain commercial water heaters in light of new test procedures is not a significant regulatory action under Executive Order 12866 or any successor order. Moreover, it would not have a significant adverse effect on the supply, distribution, or use of energy, nor has it been designated as a significant energy action by the Administrator of OIRA. Therefore, it is not a significant energy action, and, accordingly, DOE has not prepared a Statement of Energy Effects for this rulemaking.

L.Review Under Section 32 of the Federal Energy Administration Act of 1974

Under section 301 of the Department of Energy Organization Act (Pub. L. 95–91; 42 U.S.C. 7101 *et seq.*), DOE must comply with all laws applicable to the former Federal Energy Administration, including section 32 of the Federal Energy Administration Act of 1974 (Pub. L. 93-275), as amended by the Federal Energy Administration Authorization Act of 1977 (Pub. L. 95-70). (15 U.S.C. 788; FEAA) Section 32 essentially provides in relevant part that, where a proposed rule authorizes or requires use of commercial standards, the notice of proposed rulemaking must inform the public of the use and background of such standards. In addition, section 32(c) requires DOE to consult with the Attorney General and the Chairman of the Federal Trade Commission (FTC) concerning the impact of the commercial or industry standards on competition.

This proposed rule to implement conversion factors between the existing water heaters test procedure and the amended test procedure does not incorporate testing methods contained in commercial standards.

V. Public Participation

A. Submission of Comments

DOE will accept comments, data, and information regarding this proposed rule no later than the date provided in the **DATES** section at the beginning of this proposed rule. Interested parties may submit comments, data, and other information using any of the methods described in the **ADDRESSES** section at the beginning of this document.

Submitting comments via www.regulations.gov. The www.regulations.gov webpage will require you to provide your name and contact information. Your contact information will be viewable to DOE Building Technologies staff only. Your contact information will not be publicly viewable except for your first and last names, organization name (if any), and submitter representative name (if any). If your comment is not processed properly because of technical difficulties, DOE will use this information to contact you. If DOE cannot read your comment due to technical difficulties and cannot contact you for clarification, DOE may not be able to consider your comment.

However, your contact information will be publicly viewable if you include it in the comment itself or in any documents attached to your comment. Any information that you do not want to be publicly viewable should not be included in your comment, nor in any document attached to your comment. Otherwise, persons viewing comments will see only first and last names, organization names, correspondence containing comments, and any documents submitted with the comments.

Do not submit to www.regulations.gov information for which disclosure is restricted by statute, such as trade secrets and commercial or financial information (hereinafter referred to as Confidential Business Information (CBI)). Comments submitted through www.regulations.gov cannot be claimed as CBI. Comments received through the website will waive any CBI claims for the information submitted. For information on submitting CBI, see the Confidential Business Information section.

DOE processes submissions made through www.regulations.gov before posting. Normally, comments will be posted within a few days of being submitted. However, if large volumes of comments are being processed simultaneously, your comment may not be viewable for up to several weeks. Please keep the comment tracking number that www.regulations.gov provides after you have successfully uploaded your comment.

Submitting comments via email, hand delivery/courier, or mail. Comments and documents submitted via email, hand delivery/courier, or mail also will be posted to www.regulations.gov. If you do not want your personal contact information to be publicly viewable, do not include it in your comment or any accompanying documents. Instead, provide your contact information in a cover letter. Include your first and last names, email address, telephone number, and optional mailing address. The cover letter will not be publicly viewable as long as it does not include any comments

Include contact information each time you submit comments, data, documents, and other information to DOE. If you submit via mail or hand delivery/courier, please provide all items on a CD, if feasible, in which case it is not necessary to submit printed copies. No telefacsimiles (faxes) will be accepted.

Comments, data, and other information submitted to DOE electronically should be provided in PDF (preferred), Microsoft Word or Excel, WordPerfect, or text (ASCII) file format. Provide documents that are not secured, that are written in English, and that are free of any

defects or viruses. Documents should not contain special characters or any form of encryption and, if possible, they should carry the electronic signature of the author.

Campaign form letters. Please submit campaign form letters by the originating organization in batches of between 50 to 500 form letters per PDF or as one form letter with a list of supporters' names compiled into one or more PDFs. This reduces comment processing and posting time.

Confidential Business Information. Pursuant to 10 CFR 1004.11, any person submitting information that he or she believes to be confidential and exempt by law from public disclosure should submit via email, postal mail, or hand delivery/courier two well-marked copies: one copy of the document marked "confidential" including all the information believed to be confidential, and one copy of the document marked "non-confidential" with the information believed to be confidential deleted. Submit these documents via email or on a CD, if feasible. DOE will make its own determination about the confidential status of the information and treat it according to its determination.

Factors of interest to DOE when evaluating requests to treat submitted information as confidential include: (1) A description of the items; (2) whether and why such items are customarily treated as confidential within the industry; (3) whether the information is generally known by or available from other sources; (4) whether the information has previously been made available to others without obligation concerning its confidentiality; (5) an explanation of the competitive injury to the submitting person which would result from public disclosure; (6) when

such information might lose its confidential character due to the passage of time; and (7) why disclosure of the information would be contrary to the public interest.

It is DOE's policy that all comments may be included in the public docket, without change and as received, including any personal information provided in the comments (except information deemed to be exempt from public disclosure).

B. Issues on Which DOE Seeks Comment

Although DOE welcomes comments on any aspect of this proposal, DOE is particularly interested in receiving comments and views of interested parties concerning the following issues:

1. Has DOE identified all of the water heaters requiring a conversion from the old test procedures for consumer and commercial water heaters to the new test procedure for the uniform test method for measuring the energy consumption of water heaters?
2. Are the proposed analytical methods appropriate for the conversion factor analysis?
3. Is the proposed regression method appropriate for the conversion factor analysis?
4. How do manufacturers specify whether a water heater is short or tall? Is there any criteria that could be applied to compare short and tall designs across all manufacturers?
5. Is the proposed percentage difference method appropriate for the derivation of energy conservation standards based on the updated test procedure?

VI. Approval of the Office of the Secretary

The Secretary of Energy has approved publication of this notice of proposed rulemaking.

List of Subjects

10 CFR Part 429

Confidential business information, Energy conservation, Household appliances, Imports, Reporting and recordkeeping requirements.

10 CFR Part 430

Administrative practice and procedure, Confidential business information, Energy conservation, Household appliances, Imports, Incorporation by reference, Intergovernmental relations, Small businesses.

10 CFR Part 431

Administrative practice and procedure, Confidential business information, Test procedures, Incorporation by reference, Reporting and recordkeeping requirements.

Issued in Washington, DC, on March 27, 2015.

_____

Kathleen B. Hogan
Deputy Assistant Secretary for Energy Efficiency
Energy Efficiency and Renewable Energy

For the reasons stated in the preamble, DOE is proposing to amend parts 429, 430, and 431 of Chapter II, Subchapter D of Title 10, Code of Federal Regulations, as set forth below:

PART 429 – CERTIFICATION, COMPLIANCE, AND ENFORCEMENT FOR CONSUMER PRODUCTS AND COMMERCIAL AND INDUSTRIAL EQUIPMENT

1. The authority citation for part 429 continues to read as follows:

Authority: 42 U.S.C. 6291–6317.

2. Section 429.17 is revised to read as follows:

§429.17 Water heaters.

(a) Determination of represented value.

(1) As of July 13, 2015, manufacturers must determine the represented value for each new basic model of water heater by applying an AEDM in accordance with 10 CFR 429.70 or by testing for the uniform energy factor, in conjunction with the applicable sampling provisions as follows:

(i) If the represented value is determined through testing, the general requirements of 10 CFR 429.11 are applicable; and

(ii) For each basic model selected for testing, a sample of sufficient size shall be randomly selected and tested to ensure that—

(A) Any represented value of the estimated annual operating cost or other measure of energy consumption of a basic model for which consumers would favor lower values shall be greater than or equal to the higher of:

(1) The mean of the sample, where:

$$\bar{x} = \frac{1}{n}\sum_{i=1}^{n} x_i$$

and, $\bar{x}$ is the sample mean; n is the number of samples; and x_i is the ith sample;

Or,

(2) The upper 95-percent confidence limit (UCL) of the true mean divided by 1.10, where:

$$UCL = \bar{x} + t_{.95}(\frac{s}{\sqrt{n}})$$

And $\bar{x}$is the sample mean; s is the sample standard deviation; n is the number of samples; and $t_{0.95}$ is the t statistic for a 95-percent one-tailed confidence interval with n-1 degrees of freedom (from Appendix A).

and

(B) Any represented value of the uniform energy factor, energy factor, or other measure of energy consumption of a basic model for which consumers would favor higher values shall be less than or equal to the lower of:

(1) The mean of the sample, where:

$$\bar{x} = \frac{1}{n}\sum_{i=1}^{n} x_i$$

and, $\bar{x}$ is the sample mean; n is the number of samples; and x_i is the ith sample;

Or,

(2) The lower 95-percent confidence limit (LCL) of the true mean divided by 0.90, where:

$$LCL = \bar{x} - t_{.95}(\frac{s}{\sqrt{n}})$$

And $\bar{x}$is the sample mean; s is the sample standard deviation; n is the number of samples; and $t_{0.95}$ is the t statistic for a 95-percent one-tailed confidence interval with n-1 degrees of freedom (from Appendix A).

(2) For basic models initially certified before July 13, 2015 (using either the energy factor test procedure contained in Appendix E to Subpart B of 10 CFR part 430 of the January 1, 2015 edition of the Code of Federal Regulations or the thermal efficiency and standby loss test procedures contained in 10 CFR 431.106 of the January 1, 2015 edition of the Code of Federal Regulations, in conjunction with applicable sampling provisions), manufacturers must:

(i) Conduct testing for the uniform energy factor, in conjunction with the applicable sampling provisions of this paragraph;

(ii) Apply an AEDM in accordance with 10 CFR 429.70; or

(iii) Calculate the uniform energy factor by applying the following mathematical conversion factors to the previously certified value of energy factor as follows. Representations of uniform energy factor based on a calculation using this mathematical conversion factor must be equal to the uniform energy factor value resulting from the application of the appropriate equation below.

(A) The applicable mathematical conversion factors are as follows:

Product Class	Distinguishing Criteria	Conversion Factor*
Consumer Gas-fired Water Heater	Non-Condensing, Standard NOx	$New\ FHR = 1.0085 * FHR_{Ex}$ $UEF = 0.4736 + 0.2726 * UEF_{WHAM}$
	Non-Condensing, Low NOx	$New\ FHR = 4.6894 + 0.9112 * FHR_{Ex}$ $UEF = -0.0126 + 0.9966 * UEF_{WHAM}$
	Non-Condensing, Ultra-Low NOx	$New\ FHR = 2.9267 + 0.8882 * FHR_{Ex}$ $UEF = 0.2673 + 0.5811 * UEF_{WHAM}$
	Condensing	$New\ FHR = -0.7072 + 0.9724 * FHR_{Ex}$ $UEF = 0.0409 + 0.9164 * UEF_{WHAM}$
Consumer Oil-fired Water Heater	N/A	$New\ FHR = 1.1018 * FHR_{Ex}$ $UEF = -0.0945 + 1.1185 * UEF_{WHAM}$
Consumer Electric Water Heater	Electric Resistance	$New\ FHR = 11.9239 + 0.7879 * FHR_{Ex}$ $UEF = 0.1227 + 0.8673 * UEF_{WHAM}$
	Heat Pump	$New\ FHR = -2.3440 + 0.9856 * FHR_{Ex}$ $UEF = -1.1235 + 1.5485 * EF$
Tabletop Water Heater	N/A	$New\ FHR = 11.9239 + 0.7879 * FHR_{Ex}$ $UEF = 0.1227 + 0.8673 * UEF_{WHAM}$
Instantaneous Gas-fired Water Heater	N/A	$New\ Max\ GPM = 1.1467 * Max\ GPM_{Ex}$ $UEF = 0.0783 + 0.9052 * UEF_{model}$
Instantaneous Electric Water Heater	N/A	$New\ Max\ GPM = 1.1467 * Max\ GPM_{Ex}$ $UEF = 1.0079 * UEF_{model}$
Residential-Duty Commercial Gas-fired Water Heater	N/A	$New\ FHR = 39.8144 + 1.0226 * Q$ $UEF = 0.1413 + 0.7300 * UEF_{WHAM}$
Residential-Duty Commercial Oil-fired Water Heater	N/A	$New\ FHR = 39.8144 + 1.0226 * Q$ $UEF = 0.1413 + 0.7300 * UEF_{WHAM}$

*FHR_{EX} = current first-hour rating
Max GPM_{EX} = current max GPM rating
Q = nameplate input rate, in kBtu/hr
UEF_{WHAM} = the UEF predicted based on either the WHAM equation (for consumer storage water heaters) or the modified WHAM (for residential-duty commercial water heaters, as defined in the sub-paragraphs below)
UEF_{model} = the UEF predicted based on the analytical model developed by DOE (for consumer instantaneous water heaters).

(B) Calculate UEF_{WHAM} (for consumer storage water heaters and residential-duty commercial storage water heaters) and UEF_{model} (for consumer instantaneous water heaters) as follows:

(1) For consumer storage water heaters:

$$\mathrm{UEF_{WHAM}} = \left[\frac{1}{\eta_r} + \left(\frac{1}{\mathrm{EF}} - \frac{1}{\eta_r}\right)\left(\frac{\mathrm{a\ P}\ \eta_r - \mathrm{b}}{\mathrm{c\ P}\ \eta_r - \mathrm{d}}\right)\right]^{-1}$$

Where a, b, c, and d are coefficients based on the applicable draw pattern as specified in the table below; EF is the current energy factor rating; η_r is the current recovery efficiency rating in decimal form; and P is the input rating in Btu/h.

Draw Pattern	**a**	**b**	**c**	**d**
Very Small	56095146	12884892499	8930623	15125743368
Low	56095146	48962591496	33936368	57477824799
Medium	56095146	70866908744	49118427	83191588525
High	56095146	108233096990	75017235	127056244293

(2) For consumer instantaneous water heaters:

$$UEF_{model} = \frac{A}{A/\eta_r + B}$$

Where η_r is the current recovery efficiency rating expressed in decimal form and A and B are coefficients dependent upon the applicable draw pattern as specified in the table below

Draw Pattern	**A**	**B**
Very Small	5514.2	170.2
Low	20954	262.4
Medium	30328	290.9
High	46319	294.0

(3) For residential-duty commercial water heaters:

$$\mathrm{UEF_{WHAM}} = \frac{1}{1/E_t + C_1 SL}.$$

Where, E_t is the existing thermal efficiency rating; SL is the existing standby loss rating in Btu/h; and C_1 is a coefficient as specified in the table below based on the applicable draw pattern.

Draw Pattern	**C_1**
Very Small	3.575×10^{-3}
Low	9.408×10^{-4}
Medium	6.500×10^{-4}
High	4.256×10^{-4}

(3) Any represented value of the rated storage volume must be equal to the mean of the measured storage volumes of all the units within the sample.

(4) Any represented value of first-hour rating or maximum gallons per minute (GPM) must be equal to the mean of the measured first-hour ratings or measured maximum GPM ratings, respectively, of all the units within the sample.

(b) Certification reports. (1) The requirements of 10 CFR 429.12 are applicable to water heaters; and

(2) Pursuant to 10 CFR 429.12(b)(13), a certification report shall include the following public product-specific information:

(i) For storage-type water heater basic models tested for energy factor and rated pursuant to 10 CFR 429.17(a)(2)(iii): energy factor, uniform energy factor, rated storage volume (gal), first-hour rating (gal), and recovery efficiency (percent);

(ii) For storage-type water heater basic models tested for uniform energy factor and rated pursuant to 10 CFR 429.17(a)(1) or 10 CFR 429.17(a)(2)(i) through (ii): uniform energy factor, rated storage volume in gallons (gal), first-hour rating (gal), and recovery efficiency (percent);

(iii) For instantaneous-type water heater basic models tested for energy factor and rated pursuant to 10 CFR 429.17(a)(2)(iii): energy factor, uniform energy factor, rated storage volume (gal), maximum gallons per minute, and recovery efficiency (percent); and

(iv) For instantaneous-type water heater basic models tested for uniform energy factor and rated pursuant to 10 CFR 429.17(a)(1) or 10 CFR 429.17(a)(2)(i) through (ii): uniform energy factor, rated storage volume (gal), maximum gallons per minute, and recovery efficiency (percent).

3. Section 429.17 is further revised, effective [date one year after publication of final rule], to read as follows:

§429.17 Water heaters.

(a) Determination of represented value. (1) Manufacturers must determine the represented value for each water heater by applying an AEDM in accordance with 10 CFR 429.70 or by testing for the uniform energy factor, in conjunction with the applicable sampling provisions as follows:

(i) If the represented value is determined through testing, the general requirements of 10 CFR 429.11 are applicable; and

(ii) For each basic model selected for testing, a sample of sufficient size shall be randomly selected and tested to ensure that—

(A) Any represented value of the estimated annual operating cost or other measure of energy consumption of a basic model for which consumers would favor lower values shall be greater than or equal to the higher of:

(1)The mean of the sample, where:

$$\bar{x} = \frac{1}{n}\sum_{i=1}^{n} x_i$$

and, $\bar{x}$ is the sample mean; n is the number of samples; and x_i is the ith sample;

Or,

(2) The upper 95-percent confidence limit (UCL) of the true mean divided by 1.10, where:

$$UCL = \bar{x} + t_{.95}(\frac{s}{\sqrt{n}})$$

And $\bar{x}$is the sample mean; s is the sample standard deviation; n is the number of samples; and $t_{0.95}$ is the t statistic for a 95-percent one-tailed confidence interval with n-1 degrees of freedom (from Appendix A).

and

(B) Any represented value of the uniform energy factor, energy factor, or other measure of energy consumption of a basic model for which consumers would favor higher values shall be less than or equal to the lower of:

(1) The mean of the sample, where:

$$\bar{x} = \frac{1}{n}\sum_{i=1}^{n} x_i$$

and, $\bar{x}$ is the sample mean; n is the number of samples; and x_i is the ith sample;

Or,

(2) The lower 95-percent confidence limit (LCL) of the true mean divided by 0.90, where:

$$LCL = \bar{x} - t_{.95}(\frac{s}{\sqrt{n}})$$

And $\bar{x}$ s the sample mean; s is the sample standard deviation; n is the number of samples; and $t_{0.95}$ is the t statistic for a 95-percent one-tailed confidence interval with n-1 degrees of freedom (from Appendix A).

(2) Any represented value of the rated storage volume must be equal to the mean of the measured storage volumes of all the units within the sample.

(3) Any represented value of first-hour rating or maximum gallons per minute (GPM) must be equal to the mean of the measured first-hour ratings or measured maximum GPM ratings, respectively, of all the units within the sample.

(b) Certification reports. (1) The requirements of 10 CFR 429.12 are applicable to water heaters; and

(2) Pursuant to 10 CFR 429.12(b)(13), a certification report shall include the following public product-specific information:

(i) For storage-type water heater basic models: uniform energy factor, rated storage volume in gallons (gal), first-hour rating (gal), and recovery efficiency (percent);

(ii) For instantaneous-type water heater basic models: uniform energy factor, rated storage volume (gal), maximum gallons per minute, and recovery efficiency (percent); and

(iii) For instantaneous-type water heater basic models: uniform energy factor, rated storage volume (gal), maximum gallons per minute, and recovery efficiency (percent).

4. Section 429.44 is amended by:

a. Revising paragraph (a) introductory text;

b. Adding new paragraphs (c)(2)(vii) and (viii);

The revisions and additions read as follows:

§429.44 Commercial water heating equipment.

(a) For residential-duty commercial water heaters, determine representations as provided in 10 CFR 429.17(a).

* * * * *

(c) * * *

(2) * * *

(vii) Residential-duty commercial gas-fired and oil-fired storage water heaters tested for thermal efficiency and standby loss and rated pursuant to 10 CFR 429.17(a)(2)(iii): thermal efficiency in percent (%), maximum standby loss in British thermal units per hour (Btu/h), uniform energy factor, rated storage volume (gal), and the nameplate input rate in British thermal units per hour (Btu/h).

(viii) Residential-duty commercial gas-fired and oil-fired storage water heaters tested for uniform energy factor and rated pursuant to 10 CFR 429.17(a)(1) or 10 CFR 429.17(a)(2)(i) through (ii): uniform energy factor, rated storage volume (gal), first-hour rating (gal), and recovery efficiency (percent).

* * * * *

5. Section 429.44 is further revised, effective [date one year after publication of final rule], to read as follows:a. Removing paragraph (c)(2)(vii);

b. Redesignating paragraph (c)(2)(viii) as (c)(2)(vii); and

c. Revising newly redesignated paragraph (c)(2)(vii) to read as follows:

§429.44 Commercial water heating equipment.

* * * * *

(c) * * *

(2) * * *

(vii) Residential-duty commercial gas-fired and oil-fired storage water heaters: uniform energy factor, rated storage volume (gal), first-hour rating (gal), and recovery efficiency (percent).

* * * * *

PART 430 – ENERGY CONSERVATION PROGRAM FOR CONSUMER PRODUCTS

6. The authority citation for part 430 continues to read as follows:

Authority: 42 U.S.C. 6291-6309; 28 U.S.C. 2461 note.

7. Section 430.23 is amended by revising paragraph (e) to read as follows:

§430.23 Test procedures for the measurement of energy and water consumption.

*** * * * ***

(e) *Water Heaters*. (1) For water heaters tested using energy factor:

(i) The estimated annual operating cost for water heaters tested in terms of energy factor shall be—

(A) For a gas or oil water heater, the product of the annual energy consumption, determined according to section 6.1.8 or 6.2.5 of appendix E to subpart B of 10 CFR part 430 of the January 1, 2015 edition of the Code of Federal Regulations, times the representative average

unit cost of gas or oil, as appropriate, in dollars per Btu as provided by the Secretary. The resulting product shall be rounded off to the nearest dollar per year.

(B) For an electric water heater, the product of the annual energy consumption, determined according to section 6.1.8 or 6.2.5 of appendix E to subpart B to 10 CFR part 430 of the January 1, 2015 edition of the Code of Federal Regulations, times the representative average unit cost of electricity in dollars per kilowatt-hour as provided by the Secretary, divided by 3412 Btu per kilowatt-hour. The resulting quotient shall be rounded off to the nearest dollar per year.

(ii) For an individual test, the tested energy factor for a water heater shall be determined by section 6.1.7 or 6.2.4 of appendix E to subpart B of 10 CFR part 430 of the January 1, 2015 edition of the Code of Federal Regulations, rounded off to the nearest 0.01.

(2) For water heaters tested using uniform energy factor:

(i) The estimated annual operating cost shall be:

(A) For a gas or oil water heater, the sum of: the product of the annual gas or oil energy consumption, determined according to section 6.1.10 or 6.2.7 of appendix E of this subpart, times the representative average unit cost of gas or oil, as appropriate, in dollars per Btu as provided by the Secretary; plus the product of the annual electric energy consumption, determined according to section 6.1.9 or 6.2.6 of appendix E of this subpart, times the representative average unit cost of electricity in dollars per kilowatt-hour as provided by the Secretary. The resulting sum shall be rounded off to the nearest dollar per year.

(B) For an electric water heater, the product of the annual energy consumption, determined according to section 6.1.9 or 6.2.6 of appendix E of this subpart, times the

representative average unit cost of electricity in dollars per kilowatt-hour as provided by the Secretary. The resulting product shall be rounded off to the nearest dollar per year.

(ii) For an individual test, the tested uniform energy factor for a water heater shall be determined by section 6.1.7 or 6.2.4 of appendix E of this subpart, rounded to the nearest 0.01.

* * * * *

8. Section 430.32 is amended by revising paragraph (d) to read as follows:

§430.32 Energy and water conservation standards and their compliance dates.

* * * * *

(d) *Water heaters*. The energy factor of each basic model of water heater shall not be less than the following:

Product Class	**Rated Storage Volume**	**Draw Pattern**	**Uniform Energy Factor as of July 13, 2015***
Gas-fired Storage	≥ 20 gal and ≤ 55 gal	Very Small	$0.3263 - (0.0019 \text{ x } Vr)$
		Low	$0.5891 - (0.0019 \text{ x } Vr)$
		Medium	$0.6326 - (0.0013 \text{ x } Vr)$
		High	$0.7128 - (0.0025 \text{ x } Vr)$
	> 55 gal and ≤ 100 gal	Very Small	$0.5352 - (0.0007 \text{ x } Vr)$
		Low	$0.7375 - (0.0009 \text{ x } Vr)$
		Medium	$0.7704 - (0.0010 \text{ x } Vr)$
		High	$0.7980 - (0.0010 \text{ x } Vr)$
Oil-fired Storage	≤ 50 gal	Very Small	$0.2267 - (0.0014 \text{ x } Vr)$
		Low	$0.4867 - (0.0006 \text{ x } Vr)$
		Medium	$0.6016 - (0.0012 \text{ x } Vr)$
		High	$0.6529 - (0.0005 \text{ x } Vr)$
Electric Storage	≥ 20 gal and ≤ 55 gal	Very Small	$0.8268 - (0.0002 \text{ x } Vr)$
		Low	$0.9393 - (0.0004 \text{ x } Vr)$
		Medium	$0.9683 - (0.0007 \text{ x } Vr)$
		High	$0.9656 - (0.0004 \text{ x } Vr)$
	> 55 gal and ≤ 120 gal	Very Small	$1.2701 - (0.0011 \text{ x } Vr)$
		Low	$1.9137 - (0.0011 \text{ x } Vr)$
		Medium	$2.0626 - (0.0011 \text{ x } Vr)$
		High	$2.1858 - (0.0011 \text{ x } Vr)$
Tabletop Storage	≥ 20 gal and ≤	Very Small	$0.6808 - (0.0022 \text{ x } Vr)$

	100 gal	Low	$0.8770 - (0.0012 \text{ x } Vr)$
		Medium	$0.9063 - (0.0009 \text{ x } Vr)$
		High	$0.9302 - (0.0006 \text{ x } Vr)$
Gas-fired Instantaneous	< 2 gal	All	$0.8036 - (0.0019 \text{ x } Vr)$
Electric Instantaneous	< 2 gal	All	$0.9192 - (0.0013 \text{ x } Vr)$

*Vr is rated storage volume.

* * * * *

PART 431 – ENERGY EFFICIENCY PROGRAM FOR CERTAIN COMMERCIAL AND INDUSTRIAL EQUIPMENT

9. The authority citation for part 431 continues to read as follows:

Authority: 42 U.S.C. 6291-6317.

10. In §431.106 **r**evise paragraph (b) to read as follows:

§431.106 Uniform test method for the measurement of energy efficiency of commercial water heaters and hot water supply boilers (other than commercial heat pump water heaters).

* * * * *

(b) *Testing and Calculations*. Determine the energy efficiency of each class of equipment by conducting the applicable test procedure(s), set forth in the three rightmost columns of the following table:

Table 1 to §431.106 - Test Procedures for Commercial Water Heaters and Hot Water Supply Boilers (Other Than Commercial Heat Pump Water Heaters)

Equipment Type	Energy efficiency descriptor	Test Procedure	Test procedure required for compliance on and after	With these additional stipulations
Residential-Duty Commercial Water Heater	Uniform Energy Factor	10 CFR Part 430, Subpart B, Appendix E	July 13, 2015	
Gas-fired Storage and Instantaneous Water Heaters and Hot Water Supply Boilers	Thermal Efficiency	Use test set-up, equipment, and procedures in subsection labeled "Method of Test" of ANSI Z21.10.3-2011**, Exhibit G1	May 13, 2013	A. For all products, the duration of the standby loss test shall be until whichever of the following occurs first after you begin to measure the fuel and/or electric consumption: (1) The first cut-out after 24 hours or (2) 48 hours, if the water heater is not in the heating mode at that time. B. For oil and gas products, the standby loss in Btu per hour must be calculated as follows: SL (Btu per hour) = S (% per hour) × 8.25 (Btu/gal-F) × Measured Volume (gal) × 70 (degrees F). C. For oil-fired products, apply the following in conducting the thermal efficiency and standby loss tests: (1) Venting Requirements—Connect a vertical length of flue pipe to the flue gas outlet of sufficient height so as to meet the minimum draft specified by the manufacturer. (2) Oil
	Standby Loss	Use test set-up, equipment, and procedures in subsection labeled "Method of Test" of ANSI Z21.10.3-2011**, Exhibit G2	May 13, 2013	
Oil-fired Storage and Instantaneous Water Heaters and Hot Water Supply Boilers	Thermal Efficiency	ANSI Z21.10.3-2011**, Exhibit G1	May 13, 2013	
	Standby Loss	Use test set-up, equipment, and procedures in subsection labeled "Method of Test" of	May 13, 2013	

		ANSI Z21.10.3-2011**, Exhibit G2		Supply—Adjust the burner rate so that: (a) The hourly Btu input rate lies within ±2 percent of the manufacturer's specified input rate, (b) the CO_2 reading shows the value specified by the manufacturer, (c) smoke in the flue does not exceed No. 1 smoke as measured by the procedure in ASTM-D2156-80 (reference for guidance only, see §431.104), and (d) fuel pump pressure lies within ±10 percent of manufacturer's specifications. D. For electric products, apply the following in conducting the standby loss test: (1) Assume that the thermal efficiency (Et) of electric water heaters with immersed heating elements is 98 percent. (2) Maintain the electrical supply voltage to within ±5 percent of the center of the voltage range specified on the water heater nameplate. (3) If the set up includes multiple adjustable thermostats, set the highest one first to yield a maximum water temperature in the specified range as measured by the topmost tank thermocouple. Then set the lower thermostat(s) to yield a maximum mean tank temperature within the specified range.
Electric Storage and Instantaneous Water Heaters	Standby Loss	Use test set-up, equipment, and procedures in subsection labeled “Method of Test” of ANSI Z21.10.3-2011**, Exhibit G2	May 13, 2013	

				E. Install water-tube water heaters as shown in Figure 2, "Arrangement for Testing Water-tube Type Instantaneous and Circulating Water Heaters."

** Incorporated by reference, *see* §431.105.

11. Section 431.110 is revised to read as follows:

§431.110 Energy conservation standards and their effective dates.

Each commercial storage water heater, instantaneous water heater, unfired hot water storage tank and hot water supply boiler[1] (except for residential-duty commercial water heaters) must meet the applicable energy conservation standard level(s) as follows:

[1]Any packaged boiler that provides service water, that meets the definition of "commercial packaged boiler" in subpart E of this part, but does not meet the definition of "hot water supply boiler" in subpart G, must meet the requirements that apply to it under subpart E.

Product	**Size**	**Energy conservation standard[a] (products manufactured on and after October 29, 2003)[b]**	
		Minimum thermal efficiency	**Maximum standby loss[c]**
Electric storage water heaters	All	N/A	$0.30 + 27/V_m$ (%/hr)
Gas-fired storage water heaters	≤155,000 Btu/hr >155,000 Btu/hr	80% 80%	$Q/800 + 110(V_r)^{1/2}$ (Btu/hr) $Q/800 + 110(V_r)^{1/2}$ (Btu/hr)
Oil-fired storage water heaters	≤155,000 Btu/hr >155,000 Btu/hr	78% 78%	$Q/800 + 110(V_r)^{1/2}$ (Btu/hr) $Q/800 + 110(V_r)^{1/2}$ (Btu/hr)
Gas-fired instantaneous water heaters and hot water supply boilers	<10 gal ≥10 gal	80% 80%	N/A $Q/800 + 110(V_r)^{1/2}$ (Btu/hr)
Oil-fired instantaneous water heaters and hot water supply	<10 gal ≥10 gal	80% 78%	N/A $Q/800 + 110(V_r)^{1/2}$ (Btu/hr)

boilers			
Product	**Size**	**Minimum thermal insulation**	
Unfired hot water storage tank	All	R-12.5	

[a]V_m is the measured storage volume and V_r is the rated volume, both in gallons. Q is the nameplate input rate in Btu/hr.
[b]For hot water supply boilers with a capacity of less than 10 gallons: (1) the standards are mandatory for products manufactured on and after October 21, 2005, and (2) products manufactured prior to that date, and on or after October 23, 2003, must meet either the standards listed in this table or the applicable standards in subpart E of this part for a "commercial packaged boiler."
[c]Water heaters and hot water supply boilers having more than 140 gallons of storage capacity need not meet the standby loss requirement if (1) the tank surface area is thermally insulated to R-12.5 or more, (2) a standing pilot light is not used and (3) for gas or oil-fired storage water heaters, they have a fire damper or fan assisted combustion.

Each residential-duty commercial water heater, as defined in 10 CFR 431.102, must meet the applicable energy conservation standard level as follows:

Product Class	**Draw Pattern**	**Uniform Energy Factor***
Gas-fired Storage	Very Small	$0.3261-(0.0006 \times V_r)$
	Low	$0.5219-(0.0008 \times V_r)$
	Medium	$0.5585-(0.0006 \times V_r)$
	High	$0.6044-(0.0005 \times V_r)$
Oil-fired Storage	Very Small	$0.3206-(0.0006 \times V_r)$
	Low	$0.5577-(0.0019 \times V_r)$
	Medium	$0.6027-(0.0019 \times V_r)$
	High	$0.5446-(0.0018 \times V_r)$

* Vr is the rated storage volume.

[FR Doc. 2015-07932 Filed: 4/13/2015 08:45 am; Publication Date: 4/14/2015]