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Part II

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10 CFR Parts 429, 430, and 431
Energy Conservation Program for Consumer Products and Certain Commercial and Industrial Equipment: Test Procedures for Consumer and Commercial Water Heaters; Proposed Rule

DEPARTMENT OF ENERGY

10 CFR Parts 429, 430, and 431

[Docket No. 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: Supplemental notice of proposed rulemaking.

SUMMARY: The U.S. Department of Energy (DOE) proposes to establish a mathematical conversion factor to translate the current energy conservation standards and the measured values determined under the energy factor, thermal efficiency, and standby loss test procedures for consumer water heaters and certain commercial water heaters to those determined under the more recently adopted uniform energy factor test procedure. As required by the Energy Policy and Conservation Act of 1975 (EPCA), as amended, DOE initially presented proposals for establishing a mathematical conversion factor in a notice of proposed rulemaking (NOPR) published on April 14, 2015 (April 2015 NOPR). Upon further analysis and review of the public comments received in response to the April 2015 NOPR, DOE is publishing this supplemental notice of proposed rulemaking (SNOPR), which: updates the proposed mathematical conversion factors based on new test data received after the publication of the April 2015 NOPR; proposes updates to the methodology for developing the conversions for certain covered water heaters based on feedback received from interested parties; and proposes a new approach for denominating the existing energy conservation standards in terms of the new uniform energy factor (UEF) metric.

DATES: *Comments:* DOE will accept comments, data, and information regarding this SNOPR submitted no later than September 29, 2016. See section V, ''Public Participation,'' for details.

ADDRESSES: All comments submitted must identify the SNOPR for Test Procedures for the Conversion Factor for Consumer and Certain Commercial Water Heaters, and provide docket number EERE–2015–BT–TP–0007 and/or regulatory information number (RIN) 1904–AC91. Comments may be submitted using any of the following methods:

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

2. *Email: 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.

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

4. *Hand Delivery/Courier:* Ms. Ashley Armstrong, U.S. Department of Energy, Building Technologies Office, 950 L'Enfant Plaza SW., Room 6094, 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, which includes **Federal Register** notices, public meeting attendee lists and transcripts, comments, and other supporting documents/materials, is available for review at *www.regulations.gov.* All documents in the docket are listed in the *www.regulations.gov* index. However, not all documents listed in the index may be publicly available, such as those containing information that is exempt from public disclosure.

A link to the docket Web page can be found at: *https://www.regulations.gov/docket?D=EERE–2015–BT–TP–0007.* This Web page contains a link to the docket for this notice on the *www.regulations.gov* site. The *www.regulations.gov* Web page contains simple instructions on how to access all documents, including public comments, in the docket. See section V, ''Public Participation,'' for information on how to submit comments through *www.regulations.gov.*

FOR FURTHER INFORMATION CONTACT: Ms. Ashley Armstrong, U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy, Building Technologies Office, EE–5B, 1000 Independence Avenue SW., Washington, DC, 20585–0121. Telephone: (202) 586–6590. Email: *Ashley.Armstrong@ee.doe.gov.*

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

SUPPLEMENTARY INFORMATION:

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I. Authority and Background

Title III Part B [1] of the Energy Policy and Conservation Act of 1975 (''EPCA'' or, ''the Act''), Public Law 94–163 (42 U.S.C. 6291–6309, as codified) sets forth a variety of provisions designed to improve energy efficiency and established the Energy Conservation Program for 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, Public Law 94–163 (42 U.S.C. 6311–6317, as codified), added by Public Law 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, DOE's energy conservation program generally consists of four parts: (1) Testing; (2) labeling; (3) 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 certain equipment comply with any relevant standards promulgated under EPCA. (42 U.S.C. 6295(s); 42 U.S.C. 6314)

EPCA 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); 6313(a)(6)(B)(iii)(I)) Also, the Secretary may not prescribe an amended or new standard if interested persons have established by a preponderance of the evidence that the standard is likely to result in the unavailability in the United States of any covered product type (or class) of performance characteristics (including reliability), features, sizes, capacities, and volumes that are substantially the same as those generally available in the United States. (42 U.S.C. 6295(o)(4); 6313(a)(6)(B)(iii)(II))

EPCA prescribed the energy conservation standards for consumer water heaters, shown in Table I.1 (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.

TABLE I.1—EPCA INITIAL ENERGY CONSERVATION STANDARDS FOR CONSUMER WATER HEATERS

Product class	Energy factor
Gas Water Heater	0.62 − (0.0019 × Rated Storage Volume in gallons).
Oil Water Heater	0.59 − (0.0019 × Rated Storage Volume in gallons).
Electric Water Heater	0.95 − (0.00132 × Rated Storage Volume in gallons).

On October 17, 1990, DOE published a final rule which updated the test procedure from a no-draw test to a six-draw, 24-hour simulated-use test. 55 FR 42162. The effect of this change in test procedure was investigated on a sample of representative units and based on the results of testing on those units, DOE updated the energy conservation standard for electric water heaters to reflect the new test procedure. To account for the change in test procedure for electric water heaters, DOE amended the standard to 0.93 − (0.00132 × Rated Storage Volume). *Id.* at 42177. DOE notes that these statutory energy conservation standards apply to both storage and instantaneous consumer water heaters regardless of volume capacity.

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 specified classes of consumer water heaters, and maintained the existing energy conservation standards for tabletop and electric instantaneous water heaters. 75 FR 20112. The standards adopted by the April 2010 final rule are shown below in Table I.2. These standards apply to all water heater product classes listed in Table I.2 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.2—DOE 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 × V_s).
	>55 gal and ≤100 gal	0.8012 − (0.00078 × V_s).
Oil-fired Storage	≤50 gal	0.68 − (0.0019 × V_s).
Electric Storage	≥20 gal and ≤55 gal	0.96 − (0.0003 × V_s).

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

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

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

TABLE I.2—DOE ENERGY CONSERVATION STANDARDS FOR CONSUMER WATER HEATERS—Continued

Product class	Rated storage volume ***	Energy factor **
	>55 gal and ≤120 gal	2.057 − (0.00113 × V_s).
Tabletop*	≥20 gal and ≤120 gal	0.93 − (0.00132 × V_s).
Gas-fired Instantaneous	<2 gal	0.82 − (0.0019 × V_s).
Electric Instantaneous *	<2 gal	0.93 − (0.00132 × V_s).

* Tabletop and electric instantaneous water heater 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).

Water heaters that use gas, oil, electricity, or a combination of these fuels, that are not within the rated storage volume sizes stated in Table I.2 (*e.g.,* gas-fired storage less than 20 gallons or greater than 100 gallons), are subject to the applicable energy conservation standard established in EPCA.

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)) The statute was subsequently amended to require DOE to review its standards for commercial water heaters (and other ''ASHRAE equipment'') every six years. (42 U.S.C. 6313(a)(6)(C)) On January 12, 2001, DOE published a final rule for commercial water heating equipment that amended energy conservation standards by adopting the levels in ASHRAE Standard 90.1–1999 for all types of commercial water heating equipment, except for electric storage water heaters. 66 FR 3336. For electric storage water heaters, the standard in ASHRAE Standard 90.1–1999 was less stringent than the standard prescribed in EPCA and, consequently, would have increased energy consumption, so DOE maintained the standards for electric storage water heaters at the statutorily prescribed level. DOE published the most recent final rule for commercial water heating equipment on July 17, 2015, in which DOE adopted the thermal efficiency level for oil-fired storage water heaters that was included in ASHRAE 90.1–2013. 80 FR 42614. The current standards for commercial water heating equipment are presented in Table I.3.

TABLE I.3—ENERGY CONSERVATION STANDARDS FOR COMMERCIAL WATER HEATING EQUIPMENT

Equipment category	Size	Energy conservation standards*	
		Minimum thermal efficiency (equipment manufactured on and after October 9, 2015) ** † (%)	Maximum standby loss (equipment manufactured on and after October 29, 2003)** ††
Electric storage water heaters	All	N/A	0.30 + 27/V_m(%/h).
Gas-fired storage water heaters	≤155,000 Btu/h	80	Q/800 + 110(V_r)$^{1/2}$ (Btu/h).
	>155,000 Btu/h	80	Q/800 + 110(V_r)$^{1/2}$ (Btu/h).
Oil-fired storage water heaters	≤155,000 Btu/h	80†	Q/800 + 110(V_r)$^{1/2}$ (Btu/h).
	>155,000 Btu/h	80†	Q/800 + 110(V_r)$^{1/2}$ (Btu/h).
Electric instantaneous water heaters†††	<10 gal	80	N/A.
	≥10 gal	77	2.30 + 67/V_m (%/h).
Gas-fired instantaneous water heaters and hot water supply boilers.	<10 gal	80	N/A.
	≥10 gal	80	Q/800 + 110(V_r)$^{1/2}$ (Btu/h).
Oil-fired instantaneous water heater and hot water supply boilers.	<10 gal	80	N/A.
	≥10 gal	78	Q/800 + 110(V_r)$^{1/2}$ (Btu/h)
Equipment Category	**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/h.
** For hot water supply boilers with a capacity of less than 10 gallons: (1) The standards are mandatory for units manufactured on and after October 21, 2005 and (2) units manufactured on or after October 23, 2003, but prior to October 21, 2005, must meet either the standards listed in this table or the applicable standards in Subpart E of this Part for a ''commercial packaged boiler.''
† For oil-fired storage water heaters: (1) The standards are mandatory for equipment manufactured on and after October 9, 2015, and (2) equipment manufactured prior to that date must meet a minimum thermal efficiency level of 78 percent.

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

††† Energy conservation standards for electric instantaneous water heaters are included in EPCA. (42 U.S.C. 6313(a)(5)(D)–(E)) The compliance date for these energy conservation standards is January 1, 1994. In a NOPR for energy conservation standards for commercial water heating equipment published on May 31, 2016, DOE proposed to codify these standards for electric instantaneous water heaters in its regulations at 10 CFR 431.110. 81 FR 34440.

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 consumer water heaters and certain commercial water heating equipment[4] within one year of the enactment of AEMTCA. (42 U.S.C. 6295(e)(5)(B)) The final rule must replace the energy factor (EF), thermal efficiency (TE), and standby loss (SL) metrics with a uniform efficiency descriptor. (42 U.S.C. 6295(e)(5)(C)) On July 11, 2014, DOE published a final rule that fulfilled these requirements. 79 FR 40542 (July 2014 final rule). 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 for converting the measurement of efficiency from the test procedures and metrics in effect at that time to the uniform efficiency descriptor. (42 U.S.C. 6295(e)(5)(E)(i)–(ii))

EPCA provides that any covered water heater (*i.e.,* under DOE's rulemaking, all consumer water heaters and residential-duty commercial water heaters) manufactured prior to the effective date of the UEF test procedure final rule (*i.e.,* July 13, 2015) that complied with the efficiency standards and labeling requirements applicable at the time of manufacture will be considered to comply with the UEF test procedure final rule and with any revised labeling requirements established by the Federal Trade Commission (FTC) to carry out the UEF test procedure final rule. (42 U.S.C. 6295(e)(5)(K)) DOE's interpretation and application of this provision are discussed in detail in Section III.F.

As noted previously, in the July 2014 final rule, DOE amended its test procedure for consumer and certain commercial water heaters. 79 FR 40542. 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 EF, TE, and SL 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) 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 were not addressed by the previous test method); and (2) commercial water heaters that have residential applications. The major modifications to the EF 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 all storage volumes, specifically by including 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 definition for ''residential-duty commercial water heater'' and re-categorized certain commercial water heaters into this class.

This rulemaking is intended to satisfy the requirements of AEMTCA to develop a mathematical conversion factor for converting the EF, TE, and SL metrics to the UEF metric. (42 U.S.C. 6295(e)(5)(E)) As an initial step in conducting this rulemaking, DOE published a notice of proposed rulemaking on April 14, 2015, which included proposed mathematical conversion factors and proposed updates to the energy conservation standards. 80 FR 20116.

The Energy Efficiency Improvement Act of 2015 (EEIA 2015) (Pub. L. 114–11) was enacted on April 30, 2015. Among other things, EEIA 2015 added a definition of ''grid-enabled water heater'' to EPCA's energy conservation standards for consumer water heaters. (42 U.S.C. 6295(e)(6)(A)(ii)) These products are intended for use as part of an electric thermal storage or demand response program. One of the criteria in EPCA that defines a ''grid-enabled water heater'' is the requirement that it meet a certain energy factor (specified by a formula set forth in the statute), or an equivalent alternative standard that DOE may prescribe. *Id.* On August 11, 2015, DOE published a final rule in the **Federal Register** to implement the changes to EPCA by placing the energy conservation standards and related definitions in the Code of Federal Regulations (CFR). 80 FR 48004. As the energy conservation standard for grid-enabled water heaters is in terms of energy factor, DOE is addressing these products in this notice to propose a mathematical conversion and updated energy conservation standard in terms of UEF.

II. Summary of the Supplemental Notice of Proposed Rulemaking

In this SNOPR, DOE proposes to establish a mathematical conversion factor between the values determined using the EF, TE, and SL test procedures (including the first-hour rating or maximum gallons per minute (GPM) rating, as applicable), and the values that would be determined using the uniform efficiency descriptor test procedure established in the July 2014 final rule (*i.e.,* UEF and first-hour rating or maximum GPM rating). After further analysis and review of the public comments received in response to the April 2015 NOPR, DOE is publishing this SNOPR to: (1) Update the proposed mathematical conversion factors based on new test data received after the publication of the April 2015 NOPR; (2) propose to update the approaches considered for developing the conversion factors for standard and low NO_X non-condensing gas fired storage water heaters, condensing storage water heaters, tabletop water heaters, heat pump water heaters and residential-duty water heaters; and (3) propose a new approach for denominating the existing energy conservation standards in terms of the new uniform energy factor metric.

Other than the specific amendments newly proposed in this SNOPR, DOE

[4] The uniform efficiency descriptor and accompanying test procedure apply to commercial water heating equipment with residential applications defined in the test procedure final rule published July 11, 2014, as a ''residential-duty commercial water heater.'' See 79 FR 40542, 40586.

continues to propose the amendments originally included in the April 2015 NOPR. 80 FR 20116 (April 14, 2015). For the reader's convenience, DOE has reproduced in this SNOPR the entire body of latest proposed regulatory text from the April 2015 NOPR, amended as appropriate according to these proposals. DOE's supporting analysis and discussion for the portions of the proposed regulatory text not affected by this SNOPR may be found in the April 2015 NOPR.

The mathematical conversion factor required by AEMTCA is a bridge between the values[5] obtained through testing under the EF, TE, and SL test procedures and those obtained under the uniform efficiency descriptor test procedure published in the July 2014 final rule. DOE conducted a series of tests on the classes of water heaters included within the scope of this rulemaking (see section III.B for details on the scope) and relied upon that test data and test data submitted by interested parties to develop the proposals in this SNOPR. DOE used the test data, along with the approaches described in section III.C, to calculate the conversion factors proposed in this SNOPR. To develop conversion factors for this SNOPR, DOE generally used the same methodology as proposed in the April 2015 NOPR (with several exceptions discussed in more detail in section III.E.2), and presents in this document the updated conversion factors based on the inclusion of additional test data. Subsequently, DOE used the conversion factors to derive minimum energy conservation standards in terms of UEF, as shown in Table II.1 and Table II.2. For this SNOPR, DOE adopted a new approach to denominating the energy conservation standards in terms of the UEF metric, which is explained in detail in section III.E.3. The proposed standards denominated in UEF are neither more nor less stringent than the EF-denominated standards for consumer water heaters (as amended by the April 2010 final rule) and for commercial water-heating equipment based on the thermal efficiency and standby loss metrics.

TABLE II.1—PROPOSED CONSUMER WATER HEATER ENERGY CONSERVATION STANDARDS

Product class	Rated storage volume and input rating (if applicable)	Draw pattern	Uniform energy factor
Gas-fired Storage Water Heater	<20 gal	Very Small	$0.2471 - (0.0002 \times V_r)$.
		Low	$0.5132 - (0.0012 \times V_r)$.
		Medium	$0.5827 - (0.0015 \times V_r)$.
		High	$0.6507 - (0.0019 \times V_r)$.
	≥20 gal and ≤55 gal	Very Small	$0.3456 - (0.0020 \times V_r)$.
		Low	$0.5982 - (0.0019 \times V_r)$.
		Medium	$0.6483 - (0.0017 \times V_r)$.
		High	$0.6920 - (0.0013 \times V_r)$.
	>55 gal and ≤100 gal	Very Small	$0.6470 - (0.0006 \times V_r)$.
		Low	$0.7689 - (0.0005 \times V_r)$.
		Medium	$0.7897 - (0.0004 \times V_r)$.
		High	$0.8072 - (0.0003 \times V_r)$.
	>100 gal	Very Small	$0.1755 - (0.0006 \times V_r)$.
		Low	$0.4671 - (0.0015 \times V_r)$.
		Medium	$0.5719 - (0.0018 \times V_r)$.
		High	$0.6916 - (0.0022 \times V_r)$.
Oil-fired Storage Water Heater	≤50 gal	Very Small	$0.1822 - (-0.0001 \times V_r)$.
		Low	$0.5313 - (0.0014 \times V_r)$.
		Medium	$0.6316 - (0.0020 \times V_r)$.
		High	$0.7334 - (0.0028 \times V_r)$.
	>50 gal	Very Small	$0.1068 - (0.0007 \times V_r)$.
		Low	$0.4190 - (0.0017 \times V_r)$.
		Medium	$0.5255 - (0.0021 \times V_r)$.
		High	$0.6438 - (0.0025 \times V_r)$.
Electric Storage Water Heaters	<20 gal	Very Small	$0.7836 - (0.0013 \times V_r)$.
		Low	$0.8939 - (0.0008 \times V_r)$.
		Medium	$0.9112 - (0.0007 \times V_r)$.
		High	$0.9255 - (0.0006 \times V_r)$.
	≥20 gal and ≤55 gal	Very Small	$0.8808 - (0.0008 \times V_r)$.
		Low	$0.9254 - (0.0003 \times V_r)$.
		Medium	$0.9307 - (0.0002 \times V_r)$.
		High	$0.9349 - (0.0001 \times V_r)$.
	>55 gal and ≤120 gal	Very Small	$1.9236 - (0.0011 \times V_r)$.
		Low	$2.0440 - (0.0011 \times V_r)$.
		Medium	$2.1171 - (0.0011 \times V_r)$.
		High	$2.2418 - (0.0011 \times V_r)$.
	>120 gal	Very Small	$0.6802 - (0.0003 \times V_r)$.
		Low	$0.8620 - (0.0006 \times V_r)$.
		Medium	$0.9042 - (0.0007 \times V_r)$.
		High	$0.9437 - (0.0007 \times V_r)$.
Tabletop Water Heater	All	Very Small	$0.6323 - (0.0058 \times V_r)$.
		Low	$0.9188 - (0.0031 \times V_r)$.
		Medium	$0.9577 - (0.0023 \times V_r)$.
		High	$0.9884 - (0.0016 \times V_r)$.

[5] The term "represented values" includes all efficiency or performance-related information included in product ratings, nameplates, public representations (literature, product sheets, etc.).

TABLE II.1—PROPOSED CONSUMER WATER HEATER ENERGY CONSERVATION STANDARDS—Continued

Product class	Rated storage volume and input rating (if applicable)	Draw pattern	Uniform energy factor
Instantaneous Gas-fired Water Heater	<2 gal and >50,000 Btu/h	Very Small	0.7964 − (0.0000 × V_r).
		Low	0.8055 − (0.0000 × V_r).
		Medium	0.8070 − (0.0000 × V_r).
		High	0.8086 − (0.0000 × V_r).
	≥2 gal or ≤50,000 Btu/h	Very Small	0.3013 − (0.0023 × V_r).
		Low	0.5421 − (0.0024 × V_r).
		Medium	0.5942 − (0.0021 × V_r).
		High	0.6415 − (0.0017 × V_r).
Instantaneous Oil-fired Water Heater	All	Very Small	0.1430 − (0.0015 × V_r).
		Low	0.4455 − (0.0023 × V_r).
		Medium	0.5339 − (0.0023 × V_r).
		High	0.6245 − (0.0021 × V_r).
Instantaneous Electric Water Heater	All	Very Small	0.9161 − (0.0039 × V_r).
		Low	0.9159 − (0.0009 × V_r).
		Medium	0.9160 − (0.0005 × V_r).
		High	0.9161 − (0.0003 × V_r).
Grid-Enabled Water Heater	>75 gal	Very Small	1.0136 − (0.0028 × V_r).
		Low	0.9984 − (0.0014 × V_r).
		Medium	0.9853 − (0.0010 × V_r).
		High	0.9720 − (0.0007 × V_r).

*V_r is the rated storage volume which is 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	0.2670—(0.0009 × V_r).
	Low	0.5356—(0.0012 × V_r).
	Medium	0.5996—(0.0011 × V_r).
	High	0.6592—(0.0009 × V_r).
Oil-fired Storage	Very Small	0.2932—(0.0015 × V_r).
	Low	0.5596—(0.0018 × V_r).
	Medium	0.6194—(0.0016 × V_r).
	High	0.6740—(0.0013 × V_r).
Electric Instantaneous	Very Small	0.80.
	Low	0.80.
	Medium	0.80.
	High	0.80.

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

The conversion factor formulas may be used for one year beginning on the date of publication of the conversion factor final rule in the **Federal Register**. After that time, all representations regarding energy efficiency or energy use must be based on testing (either directly or through the application of an AEDM, where permitted). In addition, EPCA requires that a 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 FTC to carry out the July 2014 final rule if that water heater basic model was manufactured prior to July 13, 2015, and complied with the applicable efficiency standards and labeling requirements in effect prior to July 13, 2015. (See 42 U.S.C. 6295(e)(5)(K)) Sections III.F and III.G explain that DOE intends to address various issues related to the transition from the metrics in effect prior to July 13, 2015, through the use of enforcement policies.

III. Discussion

A. Purpose

As discussed in section I, DOE has undertaken this rulemaking to establish a mathematical conversion factor as a result of requirements added to EPCA by AEMTCA. (42 U.S.C. 6295(e)(5)) EPCA requires DOE to establish a uniform efficiency descriptor for consumer water heaters and commercial water heaters, and to establish a mathematical conversion factor to translate from the EF, TE, and SL descriptors to the uniform efficiency descriptor established by DOE. *Id.* In the July 2014 test procedure final rule, DOE established UEF as the uniform efficiency descriptor, and adopted a test method for measuring UEF for consumer and certain commercial water heaters. 79 FR 40542 (July 11, 2014). The current rulemaking addresses the mathematical conversion factor required by EPCA (see 42 U.S.C. 6295(e)(5)(E)) and the requirement that the efficiency standard be denominated according to the uniform efficiency descriptor (*i.e.,* UEF) (see 42 U.S.C. 6295(e)(5)(D)(i)).

Based on review of the test results used to develop the mathematical conversion factors, DOE has found that different water heaters are impacted in different ways by the new test method and metric, depending on the specific design and characteristics of the water heater. Water heaters have numerous attributes that impact energy efficiency and performance, and the changes to the test method and metrics impact each water heater model differently, often in ways that are difficult to predict. For example, two electric water heaters with the same rated storage volume, input rating, first-hour rating, and energy factor rating (all represented values published under the EF test method as indicators of water heater performance) have been shown by testing to have different measured first-hour ratings and uniform energy factors when tested under the new test procedure.

Given the number of models currently available in the market (756 unique basic models as of September 2015), it would not be practical to analyze each model individually to determine the change in represented values under the new test procedure. Rather, DOE has analyzed a subset of models that are representative of the market as a whole (see section III.D for further discussion of the models tested for this rule). This approach is consistent with the statutory mandate, which instructs DOE to develop ''a mathematical conversion factor.'' (42 U.S.C. 6295(e)(5)(E)) DOE recognizes that the phrase ''mathematical conversion factor'' does not require DOE to generate a single number applicable to all water heaters. For one thing, DOE believes that, despite the use of the word ''factor,'' in the singular, the statute permits the use of a conversion equation involving several numbers and mathematical operations besides multiplication. Still, the phrasing suggests that DOE should develop a formula that is broadly applicable, rather than generate a table of equivalencies stating the exact UEF equivalent for every individual product on the market.

Because each water heater is impacted differently, it would be impossible to develop a single equation, or reasonable set of equations, that could be used to model the energy performance of every water heater exactly under the new test method. Therefore, the purpose of this mathematical conversion factor is to develop an equation that will be able to reasonably predict a water heater's energy efficiency under the UEF test method based on values measured under the EF, TE, or SL test methods for that model.

Any mathematical conversion will have some amount of residual difference between predicted and measured values that is inherent when applying a mathematical equation (or multiple equations for different types of water heaters) to predict the energy efficiency performance or delivery capacity of a large set of models. In this rule, DOE has sought to minimize the amount of difference between predicted and actual performance in several ways. DOE incorporated as much test data as was practical and available, and which represented models currently on the market (see section III.D). DOE considered several attributes that could have a large impact on the test results under both the new and old metrics, and included those as appropriate when developing the mathematical conversion, which led to a set of equations for water heaters with certain different characteristics (*e.g.,* different fuel types, different nitrogen oxide (NO_X) emissions levels). DOE also explored several options for identifying the most accurate methodologies for developing the mathematical conversion equations (see section III.C). In addition, DOE sought feedback from interested parties and incorporated suggestions for improving the mathematical conversions when the suggested changes in approach resulted in conversion equations that were better predictors of actual measured performance.

As noted previously, this rulemaking also addresses the requirement that the efficiency standard be denominated in terms of UEF, and in this notice DOE proposes energy conservation standard levels using the UEF metric. (42 U.S.C. 6295(e)(5)(D)(i)) As discussed in section I, DOE may not adopt a standard that reduces the stringency of the existing standards, due to the ''anti-backsliding'' clause. (42 U.S.C. 6295(o)(1); 6313(a)(6)(B)(iii)(I)) Further, EPCA requires that the mathematical conversion factor not affect the minimum efficiency requirements. (42 U.S.C 6295(e)(5)(E)(iii)).

The methodology proposed in section III.E.3 for translating the standards is intended to ensure equivalent stringency between the existing standards (using EF, TE, and SL metrics) and the proposed updated standards (using UEF). Due to differences in water heater performance under the different test methods discussed in the preceding paragraphs, some models will perform better, and others worse, under the new test method than they did under the previous test method. Even though the stringency with respect to a specific model may vary based on the characteristics and performance of that model, the proposed approach for translating the standard is designed to maintain the same stringency for each product class as a whole. Because DOE's goal is to maintain the same stringency of the standards under the EF, TE, and SL metrics (*i.e.,* the standards in terms of the new UEF metric are neither more nor less stringent), and because individual models are impacted differentially by the change in test method and metric, some models that were previously minimally compliant will perform better than the translated UEF minimum, and others will perform worse. The possibility of such outcomes would not, by itself, mean that the conversion methodology was improper. As noted above, the possibility of some deviation for individual products is inherent in the use of a broad-based conversion equation. However, because the statute nonetheless mandates that the Department develop a ''mathematical conversion factor,'' DOE understands the statute to permit the consequences that naturally follow from that approach.

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 initially outlined the scope of this rulemaking in the April 2015 NOPR. 80 FR 20116, 20122–24 (April 14, 2015). In summary, this rulemaking includes all covered consumer water heaters, as well as commercial water heaters meeting the definition of ''residential-duty commercial water heater.'' In the NOPR, DOE stated that it was not including water heaters that were not previously subject to the test procedures or standards for energy factor established in the Code of Federal Regulations in the scope of the conversion factor, as they are not required to be tested and rated for efficiency under the DOE test method. *Id.* Table III.1 lists the consumer water heaters that, for this reason, DOE did not propose a mathematical conversion factor in the NOPR.

TABLE III.1—CONSUMER WATER HEATERS NOT COVERED IN THE NOPR 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.
Oil-fired Storage	Rated Storage Volume >50 gal.
Electric Storage	Rated Storage Volume ≥2 gal and <20 gal or >120 gallons.
Tabletop	Rated Storage Volume ≥2 gal and <20 gal or >120 gallons.
Gas-fired Instantaneous	Rated Input ≤50,000 Btu/h; Rated Storage Volume ≥2 gal.

TABLE III.1—CONSUMER WATER HEATERS NOT COVERED IN THE NOPR BY THE MATHEMATICAL CONVERSION FACTOR—Continued

Product class	Description of criteria for exclusion from conversion rulemaking
Electric Instantaneous	Rated Storage Volume ≥2 gal.
Oil-fired Instantaneous	All.

DOE has further considered the applicability of standards to the products listed in Table III.1 and proposes to clarify that the initial energy conservation standards in EPCA, as listed in Table I.1, are applicable to gas-fired, electric, and tabletop water heaters below 20 gallons storage volume; gas-fired water heaters above 100 gallons storage volume; oil-fired water heaters above 50 gallons storage volume; electric and tabletop water heaters above 120 gallons storage volume; gas-fired instantaneous water heaters with an input at or below 50,000 Btu/h or at or above 2 gallons storage volume; electric instantaneous water heaters at or above 2 gallons; and oil-fired instantaneous water heaters. These products were not considered in DOE's rulemakings that culminated in the April 16, 2010 and January 17, 2001 final rules (75 FR 20112 and 66 FR 4474, respectively), and accordingly, the standards adopted in those final rules are not applicable to these products.

DOE notes that EPCA's definitions for consumer water heaters do not place any limitation on the storage volume or specify a minimum fuel input rate for gas-fired instantaneous water heaters. Thus, DOE has tentatively concluded that the initial standards for water heaters included in EPCA were intended to cover all water heaters meeting the definition of a ''water heater'' at 42 U.S.C. 6291(27) and would apply regardless of the storage volume, and without a lower limit on the fuel input rating for gas-fired instantaneous water heaters.

In this SNOPR, DOE used the applicable conversion equations to convert the EPCA-established standards applicable to the products in Table III.1 from EF to UEF. For electric water heaters, as discussed in section I, in the October 17, 1990 test procedure final rule, DOE determined that the standard set by EPCA required adjustment under 42 U.S.C. 6293(e) due to the effect of the change in test procedure. 55 FR 42162, 42164. DOE believes the impact on measured energy characterized in the October 1990 test procedure final rule resulting from the change in the test procedure is valid for all consumer electric water heaters and not just those limited to the gallon sizes specified in the October 1990 test procedure final rule. Accordingly, DOE has used the standard level adopted in the 1990 test procedure final rule for establishing converted UEF standards for electric water heaters with storage volumes below 20 gallons and above 120 gallons.

DOE has found that oil-fired instantaneous water heaters exist on the market and are available for sale within the United States. Oil-fired instantaneous water heaters were not defined under the EF test procedure, nor were these products defined by DOE at 10 CFR 430.2 prior to the effective date of the July 2014 test procedure final rule that established the UEF metric. However, oil-fired instantaneous water heaters are defined by EPCA at 42 U.S.C. 6291(27)(B), were added to the definitions at 10 CFR 430.2 in the July 2014 test procedure final rule, and are covered by the UEF test procedure. Because oil-fired instantaneous water heaters were not previously tested to the EF test procedure, a conversion factor is not necessary (as manufacturers would not have EF ratings to convert). Rather, manufacturers of oil-fired instantaneous water heaters who wish to make representations of efficiency should test to the UEF metric. However, DOE must still convert the energy conservation standard established by EPCA from EF to UEF. The steps taken for this conversion are explained in section III.E.3.

As noted in section I, EPCA was recently amended to define and set efficiency requirements for grid-enabled water heaters in terms of EF, so DOE has included the development of a conversion factor and updated standard for these products in this SNOPR. DOE has tentatively determined that these products do not meet the criteria for exclusion from the UEF metric.

Only commercial water heaters meeting the definition of ''residential-duty commercial water heater'' are subject to the uniform efficiency descriptor test method, while all other commercial water heaters are not. As a result, this conversion only addresses commercial water heaters that meet the definition of ''residential-duty commercial water heater,'' which includes commercial water heaters that:

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

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

(3) Are 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 CONSUMER APPLICATIONS (*i.e.,* NON-RESIDENTIAL-DUTY)

Water heater type	Indicator of non-consumer application
Gas-fired Storage	Rated input >105 kBtu/h; Rated storage volume >120 gal.
Oil-fired Storage	Rated input >140 kBtu/h; Rated storage volume >120 gal.
Electric Storage	Rated input >12 kW; Rated storage volume >120 gal.
Gas-fired Instantaneous	Rated input >200 kBtu/h; Rated storage volume >2 gal.
Electric Instantaneous	Rated input >58.6 kW; Rated storage volume >2 gal.
Oil-fired Instantaneous	Rated input >210 kBtu/h; Rated storage volume >2 gal.

Additionally, DOE notes that for several types of water heaters, definitional criteria preclude their classification as residential-duty commercial water heaters. For example, an electric storage water heater with a rated input of greater than 12 kW would not be a residential-duty commercial water heater, as it is excluded under the definition of ''residential-duty commercial water heater'' based on its rated input; conversely, an input rating at or below 12 kW would place an electric storage water heater in the consumer water heater category under EPCA. (See 42 U.S.C. 6291(27)(A)). Therefore, there is no input rating at which an electric storage water heater would be classified as a residential-duty commercial water heater. Similarly, EPCA defines gas-fired instantaneous water heaters with an input of 200,000 Btu per hour or less, oil-fired instantaneous water heaters with an input of 210,000 Btu per hour or less, and heat pump type water heaters with a rated input of 12 kW or less, or a rated current of 24 amps or less at a rated voltage of not greater than 250 volts, as consumer water heaters. (42 U.S.C. 6291(27)(B)). The residential-duty commercial water heater criteria in Table III.2 exclude models with input rates above the input limits from being residential-duty commercial water heaters. Any water heaters above the applicable limits would be considered non-residential-duty commercial water heaters, and any water heaters at or below the applicable limits would be consumer water heaters. Therefore, in a NOPR for test procedures for certain commercial water heating equipment published on May 9, 2016 (''May 2016 CWH TP NOPR''), DOE is proposing to expressly exclude these four classes—electric storage water heaters, heat pump water heaters, gas-fired instantaneous water heaters, and oil-fired instantaneous water heaters—from the definition for ''residential-duty commercial water heater'' codified at 10 CFR 431.102. 81 FR 28588, 28607, 28637. Consequently, a mathematical conversion and a standard in terms of UEF are only necessary for the types of water heaters that can be defined as residential-duty commercial water heaters: gas-fired storage water heaters, oil-fired storage water heaters, and electric instantaneous water heaters.

In response to the April 2015 NOPR proposals, Air-Conditioning, Heating, and Refrigeration Institute (AHRI) commented that residential-duty commercial electric storage water heaters should have a conversion because electric water heaters that were designed with input rates less than or equal to 12 kW and deliver water at temperatures of 180 °F were previously (*i.e.,* before changes to the DOE definition for ''electric storage water heater'' were adopted in the July 2014 test procedure final rule) not considered to be consumer products. (AHRI, No. 13 at p. 6) As discussed in the preceding paragraph, there are no electric storage water heaters that would be classified as residential-duty commercial water heaters. EPCA includes as consumer electric storage water heaters those having an input rating less than or equal to 12 kW and does not distinguish between the consumer and commercial classifications by delivery temperature. (42 U.S.C. 6291(27)(A)) Therefore, electric storage water heaters with input rates at or below 12 kW are covered consumer products (rather than commercial equipment) regardless of the delivered water temperature. Thus, the product that AHRI discusses—electric storage water heaters rated at or below 12 kW but designed to deliver water at temperatures above 180 °F—would be classified as a consumer product under EPCA and would not be eligible for classification as a residential-duty commercial water heater under DOE's definitions at 10 CFR 431.102. DOE is, therefore, not proposing a conversion factor for residential-duty commercial electric storage water heaters, as there can be no such equipment. As proposed in this SNOPR, a product such as that described by AHRI would rely on the conversion that has been proposed for electric storage water heaters generally. Further, although electric storage water heaters that are designed with input ratings less than or equal to 12 kW and to deliver water at temperatures of 180 °F were not included in the consumer water heater energy factor test procedure,[6] they are consumer products. As consumer products, such water heaters are not required to be tested under the metric for commercial electric storage water heaters (*i.e.,* standby loss). Rather, since such products are classified as consumer products under the statute, DOE proposes to clarify that they should be tested and rated under the UEF test method. In the event that the UEF test method does not apply, manufacturers should submit a petition for waiver DOE (see 10 CFR 430.27) that would allow them to test and rate their products to the appropriate consumer water heater efficiency metrics. DOE is proposing in a separate rulemaking to clarify the definitions for specific kinds of consumer water heaters by removing the specifications related to the water delivery temperature. 81 FR 28636. Finally, DOE 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.

AHRI also commented that residential-duty electric instantaneous water heaters exist as defined in the UEF test procedure and, therefore, need a conversion. (AHRI, No. 13 at p. 6) DOE agrees that residential-duty commercial electric instantaneous water heaters exist on the market and that they are currently subject to the commercial water heating equipment test procedures. 10 CFR 431.106. Commercial electric instantaneous water heaters are also subject to the energy conservation standards for commercial instantaneous water heaters established in EPCA. (42 U.S.C. 6313(a)(5)(D)–(E)).[7] Specifically, for commercial instantaneous water heaters with a storage volume of less than 10 gallons, the minimum thermal efficiency is 80 percent. For commercial instantaneous water heaters with a storage volume of 10 gallons or greater, the minimum thermal efficiency is 77 percent, and the maximum standby loss is 2.30 + (67/Measured Storage Volume [in gallons]) percent per hour. Because residential-duty electric instantaneous commercial water heaters are required to have a storage volume of 2 gallons or less, the former standard level would apply to this equipment. 10 CFR 431.102. Therefore, DOE has tentatively decided to provide a mathematical conversion factor for residential-duty commercial electric instantaneous water heaters. DOE also proposes energy conservation standards for residential-duty commercial electric instantaneous water heaters denominated in the UEF metric. See section III.E.2.d for further discussion of the mathematical conversion for this equipment.

C. Approaches for Developing Conversions

This section provides the approaches that DOE is considering in developing equations to convert from prior metrics to the new metrics, including the benefits and drawbacks of each approach and details on how the equations were derived.

To develop the conversions between the prior metrics (first-hour rating,

[6] Prior to being updated by the July 11, 2014 final rule (79 FR 40542, 40567), the Uniform Test Method for Measuring the Energy Consumption of Water Heaters at appendix E to subpart B of 10 CFR 430 included a definition for ''Electric Storage-type Water Heater'' that included only, in relevant part, models designed to heat and store water at a thermostatically-controlled temperature of less than 180 °F.

[7] In a NOPR for energy conservation standards for commercial water heating equipment published on May 31, 2016, DOE proposed to codify the energy conservation standards in EPCA for commercial electric instantaneous water heaters at 10 CFR 431.110. 81 FR 34440, 34535–36.

maximum GPM, energy factor, thermal efficiency, standby loss) and the new metrics (first-hour rating, maximum GPM, uniform energy factor), DOE has broadly considered two different approaches. The first, termed ''analytical methods,'' uses equations based on the fundamental physics of water heater operation to predict how changes in test parameters lead to changes in the performance metrics. The second approach, termed ''empirical regression,'' is a purely data-driven approach that uses experimental data and regressions to develop equations that relate the prior metrics to the new ones. In addition, DOE is also considering a hybrid approach that uses both techniques.

1. Overview of Analytical Methods Approach

The analytical methods approach relies on basic equations of heat transfer and thermodynamics, as well as established understanding of the behavior of water heaters, to estimate the metric based on a set of known parameters for the water heater, environment, and test pattern. Such an approach typically yields an equation or set of equations that can be solved to ultimately yield the metric of interest, either an efficiency or delivery capacity. An attempt is then made to manipulate the equations for the metrics to yield an equation that expresses the new metrics in terms of the old metrics and other known quantities. Analytical methods have the advantage of capturing known effects on performance without conducting a series of experiments. Additionally, a properly formulated relationship would be expected to be applicable to all water heaters on the market. Analytical approaches do have some drawbacks, however. Most notably, these methods only account for factors that are known to impact performance and which can be readily estimated. There may be other phenomena that affect performance that may not be included in the known models. Second, application of these models often require assumptions about conditions. For example, one may need to assume a particular temperature of the water in the water heater despite the fact that it is known that there is variation in that temperature. Lastly, while an analytical model reduces the amount of tests needed to generate a conversion equation, a thorough set of experiments is still necessary to validate the model. Because it is based on fundamental physics, though, an analytical model can typically be extended with more confidence to a water heater that has not been tested than would a model based purely on experimental data.

Section III.C.4 discusses approaches that DOE has considered for developing analytical models to convert from prior metrics to new metrics for both delivery capacity and energy efficiency of water heaters under the uniform energy factor rating method.

2. Overview of Empirical Regression Approach

The second category of conversion factors considered by DOE is empirical regression. In this approach, a collection of water heaters is tested according to both the former test procedure and the new test procedure. The resultant performance metrics, as well as other data on the units (*e.g.,* storage volume, input rate), are compiled, and statistical techniques are used to create correlations that relate the new performance metrics to the prior metrics and characteristics. No consideration of the underlying physics is used in this approach. Rather, it is purely a data-driven method. The advantage of this approach is that the results are not biased by existing assumptions on how a water heater should behave under given conditions, with the results representing exactly what is observed in actual comparison testing. This approach should capture all factors that affect the energy efficiency and delivery capacity, even though those factors may not be known *a priori.*

Empirical regression also has some drawbacks. One drawback is that the resulting equations are most confidently applied to water heaters with attributes similar to those that were tested. Consequently, to minimize uncertainties, a large sample for testing is often appropriate to capture more fully many of the nuances in water heater design. If extended to units not sufficiently similar to those that were tested, the equations may produce unacceptably large differences between predicted and measured values if a feature on the untested model has an effect that is not captured in the experimental data. Another major drawback is that empirical regression is susceptible to experimental uncertainties. While uncertainties can be reduced through careful quality checks of experimental data, uncertainty is present in any test. The empirical regressions, being based on many samples across multiple different units, will further reduce the uncertainty, but some amount of uncertainty in the regression may be unavoidable.

Section III.C.5 presents the details of the empirical regression approaches explored by DOE.

3. Overview of Hybrid Approach

DOE has also considered a combination of the analytical methods approach and empirical regression approach, termed a hybrid approach. In this approach, a broad range of water heaters are tested, as would be done in using empirical regression. An additional factor is added to the list of attributes that is examined in the regression; this factor uses the analytical methods to first estimate the converted value. This estimate of the revised performance metric (maximum GPM, first-hour rating, or UEF) for each water heater tested is then used as an independent variable in a regression to determine the measured UEF. DOE believes that this approach takes advantage of the ability of the analytical methods approach to capture the major known factors that affect the efficiency, yet adds the additional step of regression to account for any influences that are not well described by the analytical methods.

4. Analytical Methods Approach

a. Maximum GPM

For flow-activated water heaters, the delivery capacity under the EF and UEF test procedures 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 a starting value of 58 °F ± 2 °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.

In the April 14, 2015 NOPR, DOE proposed to convert prior maximum GPM represented values to those represented values under the amended test procedure by accounting only for the change in T_{del} from 135 °F to 125 °F and for the change in the density and specific heat of water at the new delivery temperature. 80 FR 20116, 20125. The equation above can be evaluated for both delivery temperatures, and an expression for the maximum GPM under the uniform efficiency descriptor ($\dot{V}_{UED}$) as a function of the prior maximum GPM rating ($\dot{V}_{ex}$) was proposed as:

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

Northwest Energy Efficiency Alliance (NEEA) commented that the relatively simple physics associated with water flow rate and temperature rise made this conversion relatively robust, but that some anomalies were present in comparing measured and analytical ratings. (NEEA, No. 15 at p. 6) As noted in the data presented in the NOPR, DOE found this conversion equation to match well with measured data and is proposing it in a slightly modified version as the method to convert from the prior maximum GPM rating to the maximum GPM rating under the uniform energy descriptor. In the NOPR, the specific heat values were calculated using the delivery temperatures of 125 °F and 135 °F for the EF and UEF test procedures, respectively. In this SNOPR, the specific heat values are calculated using the average of the delivery temperature (*i.e.,* 125 °F and 135 °F for the EF and UEF test procedures, respectively) and the inlet temperature (*i.e.,* 58 °F for both test procedures). Further, the multiplier is shown to the fourth decimal place to be more consistent with the other equations presented in this SNOPR. Upon recalculation using appropriate values of density and specific heat, the proposed conversion equation is:

$$\dot{V}_{UED} = 1.1461\dot{V}_{ec}$$

b. First-Hour Rating

In the April 14, 2015 NOPR, DOE indicated that it was not aware of any analytical models that would mathematically represent the conversion of first-hour ratings from the prior test method to the amended test method. 80 FR 20116, 20125. NEEA questioned why DOE would make a statement in this regard, but then go on to propose a mathematical construct for doing so. (NEEA, No. 15 at p. 5) DOE notes that the mathematical construct proposed to convert first-hour ratings is based purely on regression analysis to measured data and that DOE used the terminology ''analytical model'' to represent physics-based equations that relate the two quantities. No comments were received that proposed an analytical model for converting first-hour ratings, so DOE continues to propose to use data-driven regression analysis to convert prior first-hour ratings to amended first-hour ratings, as discussed in section III.E.2.

c. Uniform Energy Factor

A number of changes to the 24-hour simulated-use test will alter the represented values of water heater energy efficiency under the prior water heater test procedures as compared to the represented values 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 to the UEF, which consists of an entirely new approach for rating efficiency.

i. Consumer Storage Water Heaters

In the April 14, 2015 NOPR, DOE proposed to use the Water Heater Analysis Model (WHAM) as a basis for conversion. 80 FR 20116, 20126–27. This model first determines the amount of energy input (Q) over a 24-hour period using the following equation:

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

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, T_{del} is the delivered water temperature, T_{in} is the inlet water temperature, 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 EF test or that required during the UEF test):

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

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. 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).

DOE received a number of comments with suggested improvements to the WHAM model. Several commenters addressed the assumption that the average tank temperature, T_{tank}, is equal to the average delivered water temperature, T_{del}. Rheem indicated that the delivered hot water temperature is greater than the average water temperature in the tank due to stratification and that the temperature difference needs to be accounted for more accurately in the analytical equations. (Rheem, No. 11 at p. 6) AHRI asked DOE to reconsider the assumption that the delivered water temperature is the same as the stored water temperature. (AHRI, No. 13 at p. 7) Bradford White added that the delivered temperature is typically close to the average tank temperature for electric water heaters, but this assumption is often not correct on gas-fired water heaters that can have a stratified tank with an average tank temperature that is much lower than the delivered temperature. (Bradford White, No. 14 at p. 2) NEEA commented that DOE has incorporated indefensible tank temperature assumptions that are far enough off to make the conversion factors significantly inaccurate, and that temperature differences between the top and bottom of tall tanks can be up to 10 °F, leading to differences between T_{del} and T_{tank} of 5 °F. (NEEA, No. 15 at p. 2)

To address these concerns, DOE examined test data and assessed the effect of changes in T_{tank} on the predictions of the WHAM analytical model. The average delivered water temperature during draws was compared to the average tank temperature during standby periods for a subset of the gas-fired and electric storage water heaters tested. For consumer electric storage water heaters, the average delivered water temperature was 6.8 °F higher than the mean tank temperature, with a standard deviation of 4.4 °F. For consumer gas-fired water heaters, the delivered water temperature was found to be only 1.5 °F greater than the average tank temperature, with a standard deviation of 4 °F. These results raise questions about the statements by commenters that the delivered water temperature is always much greater than the average tank temperature. DOE's observation in these tests is that on occasion, the delivered temperature is less than the average tank temperature that was recorded during the standby portion of the test. That observation is inconsistent with the commenters' suggestion, and DOE has identified several potential reasonable explanations for the observations. From examination of test data, it appears that there are several periods during the test when a recovery occurs such that there is an extended time following the recovery before the start of the next draw, meaning that the temperature of the water in the tank has cooled from the level it attains after a recovery. Additionally, standby periods often occur shortly after a tank recovery, meaning that the average tank temperature is relatively high during those periods. These two characteristics of the tests could certainly lead to situations where the average delivered water temperature is not always significantly greater than the average tank temperature during standby.

Next, DOE compared measured UEF values to the predictions of the WHAM model with different settings for T_{tank}. As discussed further later in this section, these WHAM predictions were also computed with different assumptions on the changes in recovery efficiency and the UA values from the EF test to the UEF test. In all cases, an assumption of T_{tank} = 125 °F resulted in lower root-mean-square deviations (RMSDs) between predicted and measured values, suggesting that an assumption of T_{tank} = 125 °F is appropriate. DOE subsequently computed WHAM predictions with T_{tank} assumed down to 110 °F and found that the assumption of T_{tank} = 125 °F held as the best predictor of measured performance.

In summary, DOE has found that a disparity between T_{tank} and T_{del} exists but not to the extent that commenters have stated. Further, using T_{tank} values below 125 °F within the WHAM model does not result in a better prediction of performance. Therefore, DOE continues to propose an assumed average tank temperature of 125 °F in the WHAM calculations that are part of the conversion of EF to UEF.

Comments were received on DOE's assumption in the WHAM model that the recovery efficiency and the UA values do not change from the EF test to the UEF test. Bradford White disagreed with the belief that the UA and recovery efficiency do not change with the change in storing water at 135 °F versus delivering at 125 °F. (Bradford White, No. 14 at p. 2) NEEA commented that the recovery efficiency of heat pump water heaters changes dramatically with different stored water temperature and disputed DOE's contention that a 7-percent change in UA is immaterial to the WHAM calculation. (NEEA, No. 15 at p. 3) DOE notes that the WHAM model is not used in the conversion that has been proposed for heat pump water heaters (rather DOE proposes the conversion derived from empirical regression), so NEEA's comment regarding the variation in recovery efficiency of heat pump water heaters is not germane to this issue. Lutz suggested a different approach for determining the key performance metrics when test conditions change from an average stored water temperature of 135 °F to an average delivered water temperature of 125 °F. (Lutz, No. 16 at pp. 4–6) Lutz recommends an approach whereby a thermal standby loss and a conversion efficiency are obtained from metrics reported in the EF test, and that these terms are used to estimate energy consumption under the UEF test.

To evaluate these suggestions, DOE first examined test data to estimate changes in both UA and recovery efficiency arising from changes in test temperature. To remove any variability in these metrics arising from changes in the procedures used to compute them, DOE focused on a subset of tests in which the same draw pattern and calculation procedure were used with the thermostats set according to the EF test procedure or the UEF test procedure. By focusing on a comparison of recovery efficiency and UA obtained during those two tests, effects of the calculation procedure are minimized to allow the focus to be placed on changes in tank temperature. It was found that the UA of both gas-fired and electric storage water heaters dropped an average of 7 percent, with a standard deviation of 3 percent. While it was assumed that the recovery efficiency of electric storage water heaters stays at 0.98, the recovery efficiency of gas-fired storage water heaters was found to increase 2 percent at a delivered temperature of 125 °F compared to a stored water temperature of 135 °F. Given these values, DOE then explored how changes in the UA value and recovery efficiency affected overall WHAM predictions of the UEF for all water heaters tested. The UA was reduced by 7 percent and the recovery efficiency increased 2 percent from their values determined in the EF test. Combinations of the different settings of UA, recovery efficiency, and T_{tank} were used (a total of 8 in all), and RMSDs were computed. The RMSD was lowest under the assumption that the UA and recovery efficiency were the same from the EF test to the UEF test. This finding held when all water heaters were grouped together, as well as when they were separated by fuel type (*i.e.,* electric and gas). While limited testing indicated that reducing the set point temperature changed the recovery efficiency and UA values, when applied to the entire dataset, the model produced predictions with lower RMSDs under the assumption of no change in recovery efficiency or UA values.

DOE also compared predictions from procedures described by Lutz to the measured data. DOE found that the RMSD when comparing all water heaters was essentially the same as for the WHAM model, with the RMSD of the Lutz approach being slightly lower for electric water heaters and slightly higher for gas-fired water heaters.

In summary, DOE found that the WHAM model provided more accurate predictions of actual performance when T_{tank} is assumed to be 125 °F and the values for UA and recovery efficiency are assumed identical under both the EF and UEF test procedures. Further, when comparing the WHAM and Lutz methods, the RMSDs were found to be essentially the same. Therefore, DOE proposes to use as the basis of its conversion factors for consumer storage water heaters the WHAM model with an assumed T_{tank} = 125 °F and an assumption that the recovery efficiency and UA values are identical under the UEF test, as they are under the EF test.

Rheem commented that the method of deriving the coefficients presented in the NOPR to determine the WHAM predictions was not clear, and AHRI stated that more information was needed on these coefficients. (Rheem, No. 11 at p. 6; AHRI, No. 13 at p. 5) In this SNOPR, DOE is presenting more details on the derivation of the equations it is proposing for converting from prior metrics to the UEF. Additionally, the coefficients are modified from the version provided in the NOPR on account of different algebraic approaches. In the equations below, variables with a subscript ''N'' refer to the UEF test procedure. Variables with a subscript ''C'' refer to the EF test procedure.

The first step is to express the UEF in terms of the delivered thermal energy and the energy consumed:

$$UEF = \frac{Q_{del,N}}{Q_N} = \frac{A}{\frac{A}{\eta_r}\left(1 - \frac{UA}{P}B\right) + 24B \cdot UA}$$

where:
$A = \rho_N C_{p,N} V_N (T_{del,N} - T_{in})$
$B = T_{tank,N} - T_{amb}$

It is assumed that the recovery efficiency and UA values are the same for both tests. The density, ρ, is evaluated at the delivery temperature, T_{del}, and the specific heat, C_p, is evaluated at the average of T_{del} and the inlet temperature, T_{in}. V is the volume delivered for the particular simulated use profile implemented during the UEF test.

The UEF equation can be rearranged to yield the following form:

$$UEF = \frac{1}{1/\eta_r + UA\left(\frac{24B}{A} - \frac{B}{P\eta_r}\right)}$$

The input power is given by the variable P. In this equation, UA is unknown, so it must be determined from the EF test. The WHAM equation for the energy consumed during the EF test, Q_C, is:

$$Q_C = \frac{\rho_C \, c_{p,C} \, V_C \, (T_{del,C} - T_{in,C})}{\eta_r}\left(1 - \frac{UA\,(T_{tank,C} - T_{amb,C})}{P}\right) + 24\,UA\,(T_{tank,C} - T_{amb,C})$$

This equation can be rearranged to yield an expression for UA:

$$UA = \frac{Q_C - D/\eta_r}{24E - DE/(\eta_r P)}$$

Where:
$D = \rho_c C_{p,c} V_c (T_{del,c} - T_{in})$
$E = (T_{tank,c} - T_{amb})$

With Q_c = D/EF, the equation above for UA can be rewritten as:

$$UA = \frac{1/EF - 1/\eta_r}{24E/D - E/(\eta_r P)}$$

Substituting this expression for UA into the equation above for UEF, one obtains the following expression for UEF:

$$UEF = \left[\frac{1}{\eta_r} + \left(\frac{1}{EF} - \frac{1}{\eta_r}\right)\left\{\frac{(24B/A)P\eta_r - B}{(24E/D)P\eta_r - E}\right\}\right]^{-1}$$

Known terms in this equation can be further grouped in the following form:

$$UEF = \left[\frac{1}{\eta_r} + \left(\frac{1}{EF} - \frac{1}{\eta_r}\right)\left\{\frac{aP\eta_r - b}{cP\eta_r - d}\right\}\right]^{-1}$$

The values for these coefficients a, b, c, and d are presented in Table III.3.

TABLE III.3—COEFFICIENTS FOR THE PROPOSED ANALYTICAL UEF CONVERSION FACTOR FOR CONSUMER STORAGE WATER HEATERS

Draw pattern	a	b	c	d
Very Small	0.250266	57.5	0.039864	67.5
Low	0.065860	57.5	0.039864	67.5
Medium	0.045503	57.5	0.039864	67.5
High	0.029794	57.5	0.039864	67.5

ii. Consumer Instantaneous Water Heater

Regarding the analytical method to convert prior represented values for consumer instantaneous water heaters to UEF, NEEA argued that technology differences can cause complications with analytical methods but did not suggest any particular improvements to the methods proposed by DOE. (NEEA, No. 15 at p. 6) AHRI stated that the determination of N*, which is the number of draws from which heat loss occurs to the environment, does not factor in the low-fire testing per the EF test procedure nor the changes in the flow rate used for the test. (AHRI, No. 8 at p. 3) DOE agrees with AHRI's observation, and is modifying its analytical model for consumer instantaneous water heaters accordingly to account for this change.

The loss factor represents the amount of energy stored in the materials making up the instantaneous water heater. Its value was obtained in the NOPR by examining test data and applying the following equation for each test:

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

In the April 2015 NOPR, DOE indicated that N* is the total number of draws during the test scaled with respect to the standby time occurring after the draw is completed. 80 FR 20116, 20127 (April 14, 2015). Those draws that are followed by less than one hour contribute a fractional value to N* that is equal to the standby time in minutes following the draw divided by 60 minutes, while the draws that are followed by one hour or more contribute a value of one to N*. To determine the loss factor (LF) from the equation above, data are obtained from the EF test, but, as AHRI notes, the N* depends upon the length of those six draws in the test. Those draws are of different length, with the first three occurring at maximum flow rate and the final three occurring at minimum flow rate. Therefore, the value of N* will not be constant for all water heaters. Instead, DOE computed a separate value of N* for each test based upon reported data on the flow rates of each draw. From these flow rates, an estimate of the length of each draw was obtained, and the standby time before the next draw could be computed. Given this adjusted technique, along with additional test data collected since the NOPR, DOE computed new loss factors. It found that loss factors were different for electric instantaneous water heaters than for gas-fired instantaneous water heaters, so it is using different analytical equations for gas-fired and electric models. The loss factor, LF, being used is 0.592 Btu/°F for gas-fired instantaneous water heaters, and LF for electric instantaneous water heaters is 0.084 Btu/°F.

The loss factor, N* for the new draw patterns of the UEF test, and the test conditions imposed in the UEF test are used with the equation above to estimate the energy consumed for a particular draw pattern for either electric or gas-fired units. The UEF can be determined as:

$$UEF_{model} = \frac{Q_{del}}{Q_{del}/\eta_r + LF \cdot N^* \cdot (T_{del} - T_{amb})}$$

The energy delivered as hot water, Q_{del} (= $\rho c_p V(T_{del} - T_{in})$), and N* depend upon the draw pattern. The delivered temperature is assumed to be 125 °F, and the ambient temperature is assumed to be 67.5 °F. This equation can be rearranged by multiplying the numerator and denominator by η_r/Q_{del}, resulting in an equation of the form:

$$UEF_{model} = \frac{\eta_r}{1 + A\eta_r}$$

where:

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

Density, ρ, is computed at the delivery temperature of 125 °F, and c_p is computed at the average of the delivery temperature and the inlet temperature, or 91.5 °F. The values for N* and A are provided in Table III.4.

TABLE III.4—N* AND COEFFICIENTS FOR THE PROPOSED ANALYTICAL UEF CONVERSION FACTOR FOR CONSUMER INSTANTANEOUS WATER HEATERS

Draw pattern	N*	A	
		Electric	Gas
Very Small	4.36	0.003819	0.026915
Low	6.72	0.001549	0.010917
Medium	7.45	0.001186	0.008362
High	7.53	0.000785	0.005534

iii. Residential-Duty Commercial Storage Water Heaters

Regarding the analytical method to convert standby loss and thermal efficiency metrics for residential-duty commercial water heaters to UEF, DOE received comments from Rheem, AHRI, and NEEA. NEEA stated that there is poor agreement between predictions and measured values and indicated that there must be some missing variables or factors, but NEEA also commented that it is not clear what those factors might be. (NEEA, No. 15 at p. 6) Rheem argued that DOE needs to replace the ''24'' multiplier with the difference between 24 and the burner on-time in the 24-hour testing period to account for the actual time of heat loss during the test. (Rheem, No. 11 at p. 6) AHRI commented that UA losses only occur when the burner is not firing, so the 24 hours should be reduced by the total burner on time over the simulated day. (AHRI, No. 13 at p. 7)

In response to NEEA's comment, DOE has evaluated the factors included in the analytical model and has not identified other terms that would increase the accuracy of the predictions. In any case, to the extent unknown factors are important, the use of regressions on top of the analytical approach should account for such factors.

DOE agrees with the comments from Rheem and AHRI and is modifying the analytical equation used to predict UEF for residential-duty water heaters to adjust the time of application of standby losses. The new equation proposed for estimating the energy consumption of a residential-duty commercial water heater as a function of standby loss, SL, thermal efficiency, E_t, and input power, P, is:

$$Q = \frac{\rho c_p V(T_{del} - T_{in})}{E_t}\left[1 - \frac{(SL/70)(T_{tank} - T_{amb})}{P}\right] + 24 \cdot \frac{SL}{70} \cdot (T_{tank} - T_{amb})$$

This equation mirrors the WHAM equation, with the second term in the square brackets removing addition of standby loss while the burner is operating. This step avoids double counting standby loss, as it is already incorporated in the thermal efficiency metric while the burner is operating. The equation can be rewritten as:

$$Q = \frac{A}{E_t}\left[1 - \frac{F \cdot SL}{P}\right] + 24F \cdot SL$$

Where $A = \rho c_p V(T_{del} - T_{in})$ and $F = (T_{tank} - T_{amb})/70$.

The UEF can be determined as $Q_{del}/Q = A/Q$. Substituting the equation for Q into this ratio yields:

$$UEF_{rd} = \frac{A}{A\left[\frac{1}{E_t} + F \cdot SL\left(\frac{24}{A} - \frac{1}{E_t P}\right)\right]}$$

Further rearranging yields the following expression for UEF:

$$UEF_{rd} = \frac{1}{\left[\frac{1}{E_t} + F \cdot SL\left(G - \frac{1}{E_t P}\right)\right]}$$

Where

G = 24/A. Values for the coefficients F and G are presented in Table III.5.

TABLE III.5—COEFFICIENTS FOR THE PROPOSED ANALYTICAL UEF CONVERSION FACTOR FOR THE RESIDENTIAL-DUTY COMMERCIAL STORAGE WATER HEATERS

Draw pattern	F	G
Very Small	0.821429	0.0043520
Low	0.821429	0.0011450
Medium	0.821429	0.0007914
High	0.821429	0.0005181

iv. Residential-Duty Commercial Electric Instantaneous Water Heaters

For the UEF conversion, DOE tentatively concluded that given the similarities between consumer electric instantaneous water heaters and residential-duty commercial electric instantaneous water heaters, the principles used to derive the consumer electric instantaneous analytical conversion apply to the residential-duty commercial equipment class as well. Therefore, DOE is proposing to use the consumer electric instantaneous mathematical conversion as a starting point for developing the residential-duty electric instantaneous conversion, with the assumption that thermal efficiency is approximately equal to recovery efficiency. Using this assumption, DOE modified the consumer electric instantaneous analytical equation to the form found below, where E_t is thermal efficiency and A is coefficient found in Table III.4. DOE proposes to use this equation as the mathematical conversion factor for residential-duty commercial electric instantaneous water heaters.

$$UEF_{rd\,model} = \frac{E_t}{1 + AE_t}$$

5. Empirical Regression Approach

As noted, the empirical regression approach does not necessarily assume any prior knowledge of water heater performance, so DOE sought an approach that would allow it to consider many factors as part of its regression equations, but would systematically eliminate any that were not shown to have a substantive impact on the resulting performance metrics. DOE selected a step regression method to accomplish this goal. The step regression method examines a series of linear equations that relate the new delivery capacity and UEF to a set of observed independent variables, such as storage volume, input rate, EF test procedure delivery capacity, recovery efficiency, energy factor, thermal efficiency, or standby loss. 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 to the actual data is chosen.

This approach eliminates factors that are not significant in converting from the EF, TE, and SL metrics to the UEF metrics, but could yield a ''best'' fit that might be more complicated than a simpler equation with a marginally worse level of match to experimental data. In addition to making the conversion equations more prone to error in implementation, a complicated equation may also include factors that would not be applicable to the entire population of water heaters. DOE, therefore, 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 differences between measured values and predicted values from the correction equations. When those differences were comparable for two different models, DOE opted for the simpler of the two, so long as it captured what would be expected to be 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.

In the April 2015 NOPR, DOE noted that it was not aware of an analytical method for determining the first-hour rating, and proposed to use an empirical regression methodology which DOE believed would be more accurate than attempting to develop an analytical method. 80 FR 20116, 20125–28 (April 14, 2015). As noted previously in section III.C.2, DOE did not receive any comments suggesting an alternate methodology for determining first-hour rating, and, thus, DOE is proposing conversion factors for those metrics and product types based on the use of the empirical regression methodology. In addition, for heat pump water heaters, DOE found that the conversion equations resulting from the analytical method and hybrid regressed-analytical approach had higher RMSD values than those resulting from the empirical regression approach (see section III.E.2.a.ii). Therefore, as proposed in the April 2015 NOPR, DOE is proposing a mathematical conversion for heat pump water heaters based on the empirical regression approach. *Id.* at 20132. (However, as discussed in section III.E.2.a.ii, this approach was modified based on comments received from interested parties.)

D. Testing Conducted for the Mathematical Conversion

This section provides an overview of the consumer and residential-duty commercial water heater markets and the test data that were available to DOE when developing the NOPR and SNOPR conversion factors.

As discussed in the April 2015 NOPR, many stakeholders commented on the importance of using actual test data in the derivation of the mathematical conversion factor. 80 FR 20116, 20121 (April 14, 2015). DOE used actual test data as part of the basis for the conversion factors and to validate the results. The models selected for testing in the April 2015 NOPR were chosen based on their characteristics being generally reflective of the broader market. In response to the April 2015 NOPR, DOE received comments suggesting areas of the market that were not adequately tested. These comments, along with DOE's responses, are discussed in detail later in this section.

For consumer and residential-duty commercial water heaters, DOE used the Compliance Certification Management System (CCMS) and crosschecked it with the AHRI directory [8] to determine the characteristics of models available on the market. DOE conducted additional research into manufacturers' literature to identify characteristics related to the water heater performance, such as the input capacity (for models not listed in the AHRI directory), venting options, tank configuration (short or tall), NO_X emissions level, ignition type (standing or non-standing pilot), and whether the model is certified for use in mobile homes. DOE also used the first-hour ratings based on the EF test procedure to attempt to predict the draw pattern that would result from the UEF test, and considered the probable draw pattern when selecting models for testing.[9] However, upon testing the models according to the UEF test method, the predicted draw pattern bin and the actual draw pattern bin did not always match up, and therefore, the actual number of models tested to each draw pattern was different than originally predicted. DOE attempted to test water heaters representative of the categories listed above, from various manufacturers, and to a similar percentage of the market across these categories (*e.g.,* DOE attempted to test approximately 8 percent of both the short and tall water heater markets, resulting in more tall units being tested due to the tall market being larger). Table III.6 shows the consumer water heater market distribution by product class, and by various attributes that commenters suggested DOE should examine. Table III.6 also shows the predicted and actual number of tested water heaters, where the predicted draw pattern of the model selected may have differed from the actual draw pattern that was used once testing was performed. Table III.7 through Table III.12 show the consumer market distribution by rated storage volume and input rate for various water heater types, along with the number of units tested for the April 2015 NOPR in each category. Table III.13 shows the market distribution for consumer heat pump water heaters by rated storage volume and EF, along with the number of units tested for the April 2015 NOPR in each category. Table III.14 and Table III.15 show the residential-duty commercial water heater market distribution by input rate and rated storage volume and the number of units tested for the April 2015 NOPR for gas-fired and oil-fired water heaters, respectively. The numbers provided below for the market and test distribution are for unique basic models, as opposed to individual model numbers, due to the addition of AHRI aggregated test data discussed further in this section. As discussed in detail immediately below, the following tables show the number of models tested for the NOPR. After the NOPR tables, are tables containing the additional number of models that DOE used for this SNOPR.

[8] The numbers presented in the following tables are from the CCMS directory as of September 2015 and the AHRI directory as of July 2015.

[9] As compared to the EF test procedure that relies on a single draw pattern, the UEF test procedure employs one of four patterns, the choice of which is determined based on the result of the first-hour rating test (for storage water heaters) or the maximum GPM rating test (for instantaneous water heaters).

TABLE III.6—CONSUMER WATER HEATER TEST DATA USED IN THE NOPR AND MARKET DISTRIBUTION BY PRODUCT TYPE AND WATER HEATER ATTRIBUTE *

Water heater type **	G–S	O–S †	E–S ††	HP–S	T–S	G–I	E–I
Total Units	21/340	2/7	9/105	5/26	2/5	17/139	5/67
Venting Options:							
Atmospheric	14/240	0/7	—	—	—	—	—
Power	7/99	—	—	—	—	17/139	—
Short or Tall:							
Short	7/94	—	2/39	—	—	—	—
Tall	14/188	2/7	7/42	—	—	—	—
NO_X Emissions:							
Standard	2/70	—	—	—	—	—	—
Low	16/199	—	—	—	—	6/33	—
Ultra-Low	3/71	—	—	—	—	11/103	—
Ignition:							
Standing Pilot	11/239	—	—	—	—	—	—
No Standing Pilot	10/100	2/7	—	—	—	12/103	—
Mobile Home Certified:							
No	21/326	2/7	9/99	5/26	2/5	16/138	5/67
Yes	0/14	—	0/6	—	—	1/1	—
Draw Pattern: †††							
Very Small	—	—	—	—	—	—	5/5/67
Low	1/0/7	—	1/3/46	0/1/1	2/2/4	1/2/2	—
Medium	10/8/161	—	7/6/54	2/3/13	0/0/1	7/8/56	—
High	10/13/172	1/2/7	0/0/5	1/1/12	—	7/7/81	—

* The information in this table is presented as the actual number of tested units/the number of models available on the market. In the draw pattern rows, the first number is the number of tested units that DOE predicted would be in each draw pattern when that unit was selected based on the unit's EF test procedure delivery capacity; the second number is the actual number of tested units in each draw pattern; and the third number is the number of models available on the market. A "—" indicates that there are no models available in the category, and, thus, there were no units tested.

** Each water heater type is abbreviated using a two part designation: For the first letter(s), "G" means gas-fired, "O" means oil-fired, "E" means electric, "HP" means heat pump, and "T" means tabletop, and for the second letter "S" means storage and "I" means instantaneous.

† Two oil-fired storage water heaters were tested, but only one is compliant with the current energy conservation standards.

†† This category includes only electric storage water heaters that use electric resistance elements, and does not include electric heat pump water heaters.

††† First-hour ratings from the EF test procedure were used to estimate draw patterns.

TABLE III.7—CONSUMER GAS-FIRED STORAGE TEST DATA USED IN THE NOPR AND MARKET DISTRIBUTION BY INPUT RATE AND RATED STORAGE VOLUME *

Input rate (kBtu/h)	Rated storage volume (gallons)								
	20	28	29	30	38	40	48	50	55
30	—	0/1 (0%)	—	0/9 (0%)	—	0/4 (0%)	—	—	—
32	—	—	1/4 (25%)	0/4 (0%)	—	0/3 (0%)	—	—	—
33	—	—	—	0/1 (0%)	—	—	—	—	—
34	—	—	—	—	—	0/7 (0%)	—	—	—
35	—	—	—	0/12 (0%)	—	0/1 (0%)	—	—	—
35.5	—	—	—	0/6 (0%)	—	0/2 (0%)	—	—	—
36	—	—	—	—	0/1 (0%)	1/10 (10%)	—	1/11 (9%)	—
37	—	—	—	—	—	0/1 (0%)	—	—	—
38	—	—	—	—	0/1 (0%)	1/17 (6%)	0/1 (0%)	0/9 (0%)	—
40	—	—	—	—	0/3 (0%)	9/85 (11%)	1/4 (25%)	1/71 (1%)	—
42	—	—	—	—	—	0/5 (0%)	—	0/8 (0%)	—
45	—	—	—	—	—	—	0/1 (0%)	1/3 (33%)	0/2 (0%)
47	—	—	—	—	—	—	—	1/3 (33%)	—
48	—	—	—	—	—	—	0/1 (0%)	—	—
50	—	—	—	—	—	0/2 (0%)	0/1 (0%)	1/8 (13%)	0/2 (0%)
55	—	—	—	—	—	—	0/1 (0%)	—	—
56	—	—	—	—	—	—	0/2 (0%)	—	—
58	—	—	—	—	—	—	—	0/1 (0%)	—
60	—	—	1/1 (100%)	—	—	—	0/5 (0%)	0/9 (0%)	0/2 (0%)
62	—	—	—	—	—	—	—	0/6 (0%)	—
65	—	—	—	—	—	—	0/5 (0%)	1/3 (33%)	—
75	0/1 (0%)	—	—	—	—	—	—	—	—

* The information in this table is presented as the number of tested units/the number of models available on the market. The percentage of models tested is in parentheses below the counts of units tested and models. A "—" indicates that there are no models available in the category, and, thus, there were no units tested.

TABLE III.8—CONSUMER ELECTRIC STORAGE TEST DATA USED IN THE NOPR AND MARKET DISTRIBUTION BY INPUT RATE AND RATED STORAGE VOLUME *

Rated storage volume (gallons)	All input rates
28	0/6 (0%)
30	1/27 (4%)
36	0/1 (0%)
38	0/6 (0%)
40	4/29 (14%)
47	0/2 (0%)
50	3/26 (12%)
52	0/2 (0%)
55	1/6 (17%)

* The information in this table is presented as the number of tested units/the number of models available on the market. The percentage of models tested is in parentheses next to the counts of units tested and models.

TABLE III.9—CONSUMER GAS-FIRED INSTANTANEOUS TEST DATA USED IN THE NOPR AND MARKET DISTRIBUTION BY INPUT RATE AND RATED STORAGE VOLUME *

Input rate (kBtu/h)	All rated storage volumes
120	1/11 (9%)
130	0/2 (0%)
140	2/9 (22%)
145	0/1 (0%)
150	1/13 (8%)
152	1/1 (100%)
157	0/7 (0%)
160	0/6 (0%)
175	1/2 (50%)
180	3/30 (10%)
190	1/9 (11%)
192	0/1 (0%)
195	0/1 (0%)
199	1/27 (4%)
199.9	2/6 (33%)
200	2/13 (15%)

* The information in this table is presented as the number of tested units/the number of models available on the market. The percentage of models tested is in parentheses next to the counts of units tested and models.

TABLE III.10—CONSUMER ELECTRIC INSTANTANEOUS TEST DATA USED FOR THE NOPR AND MARKET DISTRIBUTION BY INPUT RATE AND RATED STORAGE VOLUME *

Input rate (kW)	All rated storage volumes
2.4	1/2 (50%)
3	0/6 (0%)
3.4	0/1 (0%)
3.5	0/9 (0%)
4.1	0/3 (0%)
4.8	0/5 (0%)
5.5	0/2 (0%)
6	1/4 (25%)
6.5	0/5 (0%)
7.2	0/1 (0%)
7.5	0/3 (0%)
8	1/3 (33%)
8.3	0/3 (0%)
9	0/3 (0%)
9.5	1/6 (17%)
10	1/4 (25%)
11	0/2 (0%)
11.5	0/3 (0%)
12	0/2 (0%)

* The information in this table is presented as the number of tested units/the number of models available on the market. The percentage of models tested is in parentheses next to the counts of units tested and models.

TABLE III.11—CONSUMER TABLETOP STORAGE TEST DATA USED IN THE NOPR AND MARKET DISTRIBUTION BY INPUT RATE AND RATED STORAGE VOLUME *

Rated storage volume (gallons)	All input rates
27	1/2 (50%)
38	1/1 (100%)
40	0/2 (0%)

* The information in this table is presented as the number of tested units/the number of models available on the market. The percentage of models tested is in parentheses next to the counts of units tested and models.

TABLE III.12—CONSUMER OIL-FIRED STORAGE TEST DATA USED IN THE NOPR AND MARKET DISTRIBUTION BY INPUT RATE AND RATED STORAGE VOLUME *

Input rate (kBtu/h)	Rated storage volume (gallons)		
	30	32	50
90	—	0/2 (0%)	—
104	—	1/2 (50%)	—
105	0/2 (0%)	—	0/1 (0%)

* The information in this table is presented as the number of tested units/the number of models available on the market. The percentage of models tested is in parentheses next to the counts of units tested and models.

TABLE III.13—CONSUMER HEAT PUMP DISTRIBUTION USED FOR THE NOPR BY ENERGY FACTOR AND RATED STORAGE VOLUME *

Energy factor	Rated storage volume (gallons)							
	45	50	58	65	66	72	80	119
2.2	—	1/1 (100%)	—	—	—	—	—	—
2.21	—	—	—	—	—	—	—	0/1 (0%)
2.31	—	—	—	0/1 (0%)	—	—	0/1 (0%)	—
2.32	—	0/1 (0%)	—	—	—	—	—	—
2.33	—	—	—	—	—	—	1/1 (100%)	—
2.4	—	0/1 (0%)	—	—	—	—	—	—

TABLE III.13—CONSUMER HEAT PUMP DISTRIBUTION USED FOR THE NOPR BY ENERGY FACTOR AND RATED STORAGE VOLUME *—Continued

Energy factor	Rated storage volume (gallons)							
	45	50	58	65	66	72	80	119
2.45	0/1 (0%)	1/2 (50%)	—	—	—	0/1 (0%)	0/1 (0%)	—
2.5	—	—	—	—	0/1 (0%)	—	0/1 (0%)	—
2.72	—	—	—	—	—	—	0/1 (0%)	—
2.74	—	—	—	—	0/1 (0%)	—	—	—
2.75	—	0/1 (0%)	—	—	—	—	—	—
2.9	—	0/1 (0%)	—	—	—	—	0/1 (0%)	—
3.05	—	—	0/1 (0%)	—	—	—	—	—
3.07	—	—	—	—	—	—	0/1 (0%)	—
3.1	—	0/1 (0%)	—	—	—	—	0/1 (0%)	—
3.17	—	—	—	—	0/1 (0%)	—	—	—
3.24	—	0/1 (0%)	—	—	—	—	—	—
3.39	—	—	—	—	—	—	0/1 (0%)	—

* The information in this table is presented as the number of tested units/the number of models available on the market. The percentage of models tested is in parentheses below the counts of units tested and models. A "—" indicates that there are no models available in the category, and, thus, there were no units tested.

TABLE III.14—RESIDENTIAL-DUTY COMMERCIAL GAS-FIRED STORAGE TEST DATA USED IN THE NOPR AND MARKET DISTRIBUTION BY INPUT RATE AND RATED STORAGE VOLUME *,**

Input rate (kBtu/h)	Rated storage volume (gallons)										
	34	40	50	55	60	74	75	80	98	100	119
75	—	—	—	—	—	—	0/1 (0%)	—	—	—	—
75.1	—	—	—	—	—	0/3 (0%)	0/3 (0%)	—	0/2 (0%)	0/1 (0%)	—
76	—	—	2/4 (50%)	—	0/2 (0%)	—	2/21 (10%)	0/2 (0%)	—	0/3 (0%)	—
78	—	—	—	0/1 (0%)	—	—	—	—	—	—	—
80	—	—	—	0/2 (0%)	—	0/1 (0%)	0/1 (0%)	—	—	1/1 (100%)	—
85	—	—	—	—	—	—	—	—	—	0/3 (0%)	—
88	—	—	—	—	—	—	—	—	—	0/3 (0%)	—
90	—	—	—	—	—	—	—	—	0/1 (0%)	—	—
91.3	—	0/1 (0%)	—	—	—	—	—	—	—	—	—
98	—	—	0/2 (0%)	—	—	—	—	—	—	—	—
100	0/1 (0%)	—	0/1 (0%)	0/3 (0%)	—	—	0/2 (0%)	0/2 (0%)	—	—	0/2 (0%)

* The information in this table is presented as the number of tested units/the number of models available on the market. The percentage of models tested is in parentheses below the counts of units tested and models. A "—" indicates that there are no models available in the category, and, thus, there were no units tested.

** Seven data points were presented in the April 2015 NOPR, but two units were of the same basic model, and three units were tested to the incorrect input rate. DOE has removed these data points from the analysis.

TABLE III.15—RESIDENTIAL-DUTY COMMERCIAL OIL-FIRED STORAGE TEST DATA USED IN THE NOPR AND MARKET DISTRIBUTION BY INPUT RATE AND RATED STORAGE VOLUME *,**

Input rate (kBtu/h)	Rated storage volume (gallons)		
	30	50	70
119	0/2 (0%)	0/1 (0%)	0/1 (0%)
140	—	0/1 (0%)	—

* The information in this table is presented as the number of tested units/the number of models available on the market. The percentage of models tested is in parentheses below the counts of units tested and models. A "—" indicates that there are no models available in the category, and, thus, there were no units tested.

In addition, AHRI submitted test results for testing conducted under both the EF and UEF test methods by its member manufacturers. (AHRI, No. 9) As using additional data points will generally reduce the uncertainty in the statistical modeling used to generate the conversion factor, DOE has incorporated the test data submitted by AHRI in its analysis for this SNOPR. DOE also conducted additional testing, which was completed after the publication of the April 2015 NOPR, and is including the results in this SNOPR. Table III.16 shows the consumer market distribution by product class and attributes that commenters suggested DOE examine, along with the number of units tested for the development of this SNOPR in each category. Table III.17 through Table III.21 show the consumer market distribution by rated storage volume and input rate for various water heater categories and the number of units tested for this SNOPR in each category. Table III.22 shows the consumer heat pump market distribution by rated storage volume and EF and the number of units tested for this SNOPR in each category. Table III.23 and Table III.24 show the residential-duty commercial market distribution by input rate and rated storage volume and the number of units tested for this SNOPR in each category. AHRI did not supply model numbers in its data, so some percentages in the tables below are greater than 100 percent, suggesting that DOE and AHRI have data on the same water heaters. Both the DOE and AHRI data sets contain some test points that are from different water heaters of the same model. These models were only counted once in the tables below, and the test data were averaged into a single data point in the conversion factor derivation.

TABLE III.16—CONSUMER MARKET DISTRIBUTION AND TEST DATA USED FOR THIS SNOPR BY PRODUCT TYPE AND WATER HEATER ATTRIBUTE*

Water heater type **	G–S	O–S †	E–S ††	HP–S	T–S	G–I	E–I
Total Units	118/340	2/7	46/105	16/26	3/5	53/139	5/67
Venting Options							
Atmospheric	84/240	0/7	—	—	—	—	—
Power	33/99	—	—	—	—	53/139	—
Short or Tall							
Short	42/94	—	11/39	—	—	—	—
Tall	75/188	2/7	19/42	—	—	—	—
NO_X Emissions							
Standard	13/70	—	—	—	—	—	—
Low	81/199	—	—	—	—	9/33	—
Ultra-Low	24/71	—	—	—	—	44/103	—
Ignition							
Standing Pilot	76/239	—	—	—	—	—	
No Standing Pilot	41/100	2/7	—	—	—	48/103	—
Mobile Home Certified							
No	118/326	2/7	46/99	16/26	3/5	52/138	5/67
Yes	0/14	—	0/6	—	—	1/1	—
Draw Pattern †††							
Very Small	—	—	—	—	—	—	5/5/67
Low	4/2/7	—	12/13/46	0/1/1	3/2/4	1/2/2	—
Medium	55/55/161	—	31/32/54	7/9/13	0/1/1	13/21/56	—
High	59/61/172	1/2/7	4/1/5	6/6/12	—	18/30/81	—

* The information in this table is presented as the actual number of tested units/the number of models available on the market. In the draw pattern rows, the first number is the number of tested units that DOE predicted would be in each draw pattern when that unit was selected based on the unit's EF test procedure delivery capacity; the second number is the actual number of tested units in each draw pattern; and the third number is the number of models available on the market. A "—" indicates that there are no models available in the category, and, thus, there were no units tested.

** Each water heater type is abbreviated using a two part designation: For the first letter(s) "G" means gas-fired, "O" means oil-fired, "E" means electric, "HP" means heat pump, and "T" means tabletop, and for the second letter "S" means storage and "I" means instantaneous.

† Two oil-fired storage water heaters were tested, but only one is compliant with the current energy conservation standards.

†† In this table, this category includes only electric storage water heaters that use electric resistance elements, and does not include electric heat pump water heaters.

†† First-hour ratings from the EF test procedure were used to estimate draw patterns.

TABLE III.17—CONSUMER GAS-FIRED STORAGE DISTRIBUTION AND TEST DATA USED FOR THIS SNOPR BY INPUT RATE AND RATED STORAGE VOLUME *

Input rate (kBtu/h)	Rated storage volume (gallons)								
	20	28	29	30	38	40	48	50	55
30	—	1/1 (100%)	—	6/9 (67%)	—	1/4 (25%)	—	—	—
32	—	—	2/4 (50%)	3/4 (75%)	—	0/3 (0%)	—	—	—
33	—	—	—	1/1 (100%)	—	—	—	—	—
34	—	—	—	—	—	3/7 (43%)	—	—	—
35	—	—	—	0/12 (0%)	—	0/1 (0%)	—	—	—
35.5	—	—	—	2/6 (33%)	—	0/2 (0%)	—	—	—
36	—	—	—	—	1/1 (100%)	4/10 (40%)	—	3/11 (27%)	—
37	—	—	—	—	—	0/1 (0%)	—	—	—
38	—	—	—	—	0/1 (0%)	8/17 (47%)	0/1 (0%)	5/9 (56%)	—
40	—	—	—	—	1/3 (33%)	29/85 (34%)	3/4 (75%)	24/71 (34%)	—
42	—	—	—	—	—	0/5 (0%)	—	3/8 (38%)	—
45	—	—	—	—	—	—	0/1 (0%)	2/3 (67%)	1/2 (50%)
47	—	—	—	—	—	—	—	1/3 (33%)	—
48	—	—	—	—	—	—	0/1 (0%)	—	—
50	—	—	—	—	—	0/2 (0%)	1/1 (100%)	3/8 (38%)	1/2 (50%)
55	—	—	—	—	—	—	0/1 (0%)	—	—
56	—	—	—	—	—	—	0/2 (0%)	—	—
58	—	—	—	—	—	—	—	0/1 (0%)	—

TABLE III.17—CONSUMER GAS-FIRED STORAGE DISTRIBUTION AND TEST DATA USED FOR THIS SNOPR BY INPUT RATE AND RATED STORAGE VOLUME *—Continued

Input rate (kBtu/h)	Rated storage volume (gallons)								
	20	28	29	30	38	40	48	50	55
60	—	—	2/1 (200%)	—	—	—	1/5 (20%)	0/9 (0%)	0/2 (0%)
62	—	—	—	—	—	—	—	1/6 (17%)	—
65	—	—	—	—	—	—	2/5 (40%)	2/3 (67%)	—
75	0/1 (0%)	—	—	—	—	—	—	—	—

* The information in this table is presented as the number of tested units/the number of models available on the market. The percentage of models tested is in parentheses below the counts of units tested and models. A "—" indicates that there are no models available in the category, and, thus, there were no units tested.

TABLE III.18—CONSUMER ELECTRIC STORAGE DISTRIBUTION AND TEST DATA USED FOR THIS SNOPR BY INPUT RATE AND RATED STORAGE VOLUME *

Rated storage volume (gallons)	All input rates
28	5/6 (83%)
30	6/27 (22%)
36	0/1 (0%)
38	2/6 (33%)
40	12/29 (41%)
47	0/2 (0%)
50	15/26 (58%)
52	1/2 (50%)
55	4/6 (67%)

* The information in this table is presented as the number of tested units/the number of models available on the market. The percentage of models tested is in parentheses next to the counts of units tested and models.

TABLE III.19—CONSUMER GAS-FIRED STORAGE DISTRIBUTION AND TEST DATA USED FOR THIS SNOPR BY INPUT RATE AND RATED STORAGE VOLUME *

Input rate (kBtu/h)	All rated storage volumes
120	4/11 (36%)
130	0/2 (0%)
140	5/9 (56%)
145	0/1 (0%)
150	4/13 (31%)
152	3/1 (300%)
157	2/7 (29%)
160	0/6 (0%)
175	1/2 (50%)
180	9/30 (30%)
190	5/9 (56%)
192	0/1 (0%)
195	0/1 (0%)
199	6/27 (22%)
199.9	10/6 (167%)
200	2/13 (15%)

* The information in this table is presented as the number of tested units/the number of models available on the market. The percentage of models tested is in parentheses next to the counts of units tested and models.

TABLE III.20—CONSUMER TABLETOP STORAGE DISTRIBUTION AND TEST DATA USED FOR THIS SNOPR BY INPUT RATE AND RATED STORAGE VOLUME *

Rated storage volume (gallons)	All input rates
27	1/2 (50%)
38	1/1 (100%)
40	1/2 (50%)

* The information in this table is presented as the number of tested units/the number of models available on the market. The percentage of models tested is in parentheses next to the counts of units tested and models.

TABLE III.21—CONSUMER OIL-FIRED STORAGE DISTRIBUTION AND TEST DATA USED FOR THIS SNOPR BY INPUT RATE AND RATED STORAGE VOLUME *

Input rate (kBtu/h)	Rated storage volume (gallons)		
	30	32	50
90		0/2 (0%)	
104		1/2 (50%)	
105	0/2 (0%)		0/1 (0%)

* The information in this table is presented as the number of tested units/the number of models available on the market. The percentage of models tested is in parentheses next to the counts of units tested and models.

TABLE III.22—CONSUMER HEAT PUMP DISTRIBUTION AND TEST DATA USED FOR THIS SNOPR BY ENERGY FACTOR AND RATED STORAGE VOLUME *

Energy factor	Rated storage volume (gallons)							
	45	50	58	65	66	72	80	119
2.2	—	1/1 (100%)	—	—	—	—	—	—
2.21	—	—	—	—	—	—	—	1/1 (100%)
2.31	—	—	—	1/1 (100%)	—	—	1/1 (100%)	—
2.32	—	0/1 (0%)	—	—	—	—	—	—
2.33	—	—	—	—	—	—	2/1 (200%)	—

TABLE III.22—CONSUMER HEAT PUMP DISTRIBUTION AND TEST DATA USED FOR THIS SNOPR BY ENERGY FACTOR AND RATED STORAGE VOLUME *—Continued

Energy factor	Rated storage volume (gallons)							
	45	50	58	65	66	72	80	119
2.4	—	2/1 (200%)	—	—	—	—	—	—
2.45	0/1 (0%)	1/2 (50%)	—	—	—	0/1 (0%)	0/1 (0%)	—
2.5	—	—	—	—	0/1 (0%)	—	0/1 (0%)	—
2.72	—	—	—	—	—	—	1/1 (100%)	—
2.74	—	—	—	—	0/1 (0%)	—	—	—
2.75	—	0/1 (0%)	—	—	—	—	—	—
2.9	—	1/1 (100%)	—	—	—	—	1/1 (100%)	—
3.05	—	—	0/1 (0%)	—	—	—	—	—
3.07	—	—	—	—	—	—	0/1 (0%)	—
3.1	—	0/1 (0%)	—	—	—	—	1/1 (100%)	—
3.17	—	—	—	—	0/1 (0%)	—	—	—
3.24	—	0/1 (0%)	—	—	—	—	—	—
3.39	—	1/0 **	—	—	—	—	0/1 (0%)	—

* The information in this table is presented as the number of tested units/the number of models available on the market. The percentage of models tested is in parentheses below the counts of units tested and models. A "—" indicates that there are no models available in the category, and, thus, there were no units tested.

** AHRI supplied data for this model which is not contained in the version of the CCMS and AHRI databases used for this SNOPR. Due to the high rated EF, DOE believes this unit to have recently come on to the market.

TABLE III.23—RESIDENTIAL-DUTY COMMERCIAL GAS-FIRED STORAGE TEST DATA USED FOR THIS SNOPR AND MARKET DISTRIBUTION BY INPUT RATE AND RATED STORAGE VOLUME *

Input rate (kBtu/h)	Rated storage volume (gallons)										
	34	40	50	55	60	74	75	80	98	100	119
75	—	—	—	—	—	—	0/1 (0%)	—	—	—	—
75.1	—	—	—	—	—	2/3 (67%)	1/3 (33%)	—	3/2 (150%)	0/1 (0%)	—
76	—	—	6/4 (150%)	—	0/2 (0%)	—	2/21 (10%)	0/2 (0%)	—	0/3 (0%)	—
78	—	—	—	0/1 (0%)	—	—	—	—	—	—	—
80	—	—	—	0/2 (0%)	—	0/1 (0%)	1/1 (100%)	—	—	1/1 (100%)	—
85	—	—	—	—	—	—	—	—	—	1/3 (33%)	—
88	—	—	—	—	—	—	—	—	—	0/3 (0%)	—
90	—	—	—	—	—	—	—	—	0/1 (0%)	—	—
91.3	—	0/1 (0%)	—	—	—	—	—	—	—	—	—
98	—	—	0/2 (0%)	—	—	—	—	—	—	—	—
100	0/1 (0%)	—	1/1 (100%)	0/3 (0%)	—	—	1/2 (50%)	0/2 (0%)	—	—	0/2 (0%)

* The information in this table is presented as the number of tested units/the number of models available on the market. The percentage of models tested is in parentheses below the counts of units tested and models. A "—" indicates that there are no models available in the category, and, thus, there were no units tested.

TABLE III.24—RESIDENTIAL-DUTY COMMERCIAL OIL-FIRED STORAGE TEST DATA USED FOR THIS SNOPR AND MARKET DISTRIBUTION BY INPUT RATE AND RATED STORAGE VOLUME *

Input rate (kBtu/h)	Rated storage volume (gallons)		
	30	50	70
119	0/2 (0%)	0/1 (0%)	0/1 (0%)
140	—	1/1 (100%)	—

* The information in this table is presented as the number of tested units/the number of models available on the market. The percentage of models tested is in parentheses below the counts of units tested and models. A "—" indicates that there are no models available in the category, and, thus, there were no units tested.

As noted above, DOE received a number of comments suggesting types of water heaters for which the commenters said DOE should incorporate additional data for the development of the conversion factors. Specifically, AHRI and Rheem stated that more short units should be tested and in particular, electric short units. (AHRI, No. 13 at p. 5; Rheem, No. 11 at p. 7) For the SNOPR, the percentage of gas-fired and electric short water heater models on the market that have been tested has increased from 7 percent to 45 percent and from 5 percent to 28 percent, respectively, as compared to the April 2015 NOPR. DOE notes that these percentages are based on identification in manufacturer literature, as there is no consistent, objective criteria for identifying short and tall models across manufacturers. DOE believes that the models tested are representative of ''short'' models available on the market.

AHRI stated that units subject to the low draw pattern for the consumer electric storage category were not adequately tested. (AHRI, No. 13 at p. 5) Rheem also stated that not enough consumer electric storage units were tested, but that more testing for the high-draw-pattern category was needed. (Rheem, No. 13 at p. 7) As noted above, the draw pattern classification for DOE's test unit selection was based upon the first-hour ratings based on the EF test procedure, as the first-hour ratings under the UEF test procedure are not readily available in published literature. However, the actual draw pattern for each unit tested was found experimentally through testing for the first-hour rating under the UEF test method prior to conducting the UEF simulated-use test. For the SNOPR, the percentage of electric low- and high-draw-pattern water heaters on the market that have been tested has increased from 7 percent to 28 percent and from 0 percent to 20 percent, respectively. These percentages are based on the number of units that were determined through testing to be in a draw pattern bin as compared to the number of models that would be predicted to be in that draw pattern bin.

Rheem stated that no low-draw-pattern consumer gas-fired water heaters were tested. (Rheem, No. 13 at p. 7) DOE predicted seven of the 340 (*i.e.*, 2.1 percent) gas-fired water heater models on the market to be in the low-draw-pattern bin based on their EF test procedure first-hour rating. For the NOPR, one unit was tested with an expected low-draw-pattern based on its first-hour rating under the EF test procedure, but that unit's tested first-hour rating under the new UEF procedure placed it into the medium-draw-pattern bin. Subsequently, two consumer gas-fired water heaters were supplied in the AHRI dataset and tested to the low-draw-pattern bin under the UEF first-hour rating test. Therefore, two low-draw-pattern tests are now available and were included in the analysis.

Rheem stated that there were no tests of consumer gas-fired storage water heaters above 55 gallons. (Rheem, No. 13 at p. 7) In response, DOE notes that as of the time of this analysis, there are no water heaters on the market which would fall into this category.

AHRI and Rheem suggested that more ultra-low NO_X units should be tested. (AHRI, No. 13 at p. 5; Rheem, No. 11 at p. 7) For the SNOPR, the percentage of ultra-low NO_X gas-fired water heaters on the market that have been tested has increased from 4 percent to 34 percent.

AHRI, GE, and Rheem suggested that more high-EF heat pump units should be tested. (AHRI, No. 8 at p. 4; GE, No. 12 at p. 1; Rheem, No. 11 at p. 7) For the SNOPR, the percentage of high-EF (*i.e.*, EF greater than 2.7) heat pump water heaters on the market that have been tested has increased from 0 percent to 42 percent.

AHRI and Rheem commented that the sample size for the residential-duty gas-fired storage category was too small. (AHRI, No. 13 at p. 6; Rheem, No. 11 at p. 7) AHRI and Rheem also stated that no residential-duty units in the high-input range were tested. (AHRI, No. 8 at p. 4; Rheem, No. 11 at p. 7) For the SNOPR, the percentage of residential-duty commercial gas-fired storage water heaters on the market that have been tested has increased from 7 percent to 28 percent, and the percentage of high-input (*i.e.*, input rate greater than 90,000 Btu/h) units has increased from 0 percent to 14 percent.

1. Repeatability

In response to the April 2015 NOPR, commenters stated that the repeatability of the UEF test procedure was not analyzed. (AHRI, No. 8 at p. 5; Rheem, No. 11 at p. 6) In response, DOE acknowledges that each water heater was tested once, and repeat tests of the same unit were not conducted by DOE. During its test procedure rulemaking to establish the UEF test method, stakeholders did not raise concerns regarding repeatability, and, therefore, DOE did not specifically evaluate this issue during testing conducted for the NOPR. However, AHRI submitted data that appears to show the variations in the experimental results from testing a given unit are unlikely to contribute more than a *de minimis* amount of uncertainty to the overall regression. One consumer electric storage water heater (Test ID No. 1–61 and 1–62) and one consumer gas-fired instantaneous water heater (Test ID No. 1–83 and 1–84) were tested multiple times. For the consumer electric storage water heater, the only difference between the two tests was the result of the EF test procedure's first-hour rating test (difference of 3 gallons). For the gas-fired instantaneous water heater, the differences in the EF test procedure maximum GPM, EF, UEF test procedure maximum GPM, and UEF results were 0.019 gpm, 0.0017, 0.0002 gpm, and 0.0012, respectively. (AHRI, No. 9 Attachment) These data suggest that the EF and UEF test procedures are repeatable.

For this SNOPR, DOE conducted additional testing that allowed DOE to further examine the repeatability of the test method. DOE tested eight units, two different units of one model and 3 different units of 2 other models. Because the different units may have slightly different EF or UEF characteristics, the variability in these results is an upper bound for the variability introduced by the test methods themselves. The variability was similar for all three, and DOE has no reason to think the test methods would produce significantly different levels of variability for other types of water heaters. The results of the testing are shown in Table III.25. The standard deviations of the EF and UEF tests for models 1, 2, and 3 are 0.0018 and 0.0035, 0.0033 and 0.0044, and 0.0149 and 0.0116, respectively. These standard deviations are all within the same magnitude for each model and for the case of model 3 the UEF standard deviation is less than EF. The results indicate a reasonable level of repeatability in the test procedure.

TABLE III.25—RESULTS FOR REPEATABILITY TESTING FOR EF AND UEF TEST METHODS

Model	Unit	Rated EF	Tested EF	Tested UEF
1	1	0.95	0.947	.949
1	2	0.95	0.949	.944
2	1	0.95	0.937	.903
2	2	0.95	0.940	.909
2	3	0.95	0.934	.901
3	1	0.95	0.908	.914
3	2	0.95	0.932	.898
3	3	0.95	0.905	.892

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 prior 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 would warrant separate conversion equations. DOE investigated attributes such as: (1) NO_X emission level; (2) short or tall configuration; (3) vent type; (4) standing pilot versus electronic ignition; (5) whether condensing or heat pump technology is used; and (6) whether the unit is tabletop. The RMSD between the measured values and the values obtained through various conversion methods was compared. The conversion approach with the lowest cumulative RMSD value for a particular fuel type was considered to be the best candidate for the conversion equation.

In the April 2015 NOPR, DOE proposed to adopt different conversion equations based on the level of NO_X emissions. 80 FR 20116, 20129–30 (April 14, 2015). 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 less than 40 ng/J 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). AHRI commented that separate conversions for standard and low-NO_X water heaters are not needed. (AHRI, No. 8 at p. 4) As a result, DOE re-examined the data to determine the variability of the conversions when considering standard and low-NO_X water heaters together, and separately from ultra-low-NO_X water heaters. DOE found that the combined approach recommended by AHRI slightly reduces the variability of the conversion equations, and, thus, the Department has included standard and low-NO_X water heaters in a single set of conversion equations in this supplemental proposal. The proposal continues to treat ultra-low-NO_X water heaters separately, because an ultra-low-NO_X burner has a fundamentally different design than standard and low-NO_X burners and the resulting RMSD values are lower for each category when separated.

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 ''short'' are actually taller than units labeled as ''tall.'' In the NOPR, DOE requested comment on how manufacturers determine whether a unit is short or tall. 80 FR 20116, 20129 (April 14, 2015). No response was received related to this inquiry, so DOE considered manufacturer literature in determining whether a model was ''tall'' or ''short,'' although as noted, the criteria for classification was not always consistent across manufacturers. DOE examined separate conversions for tall and short water heaters based on their identification in manufacturer literature; however, DOE ultimately did not propose separate conversions because it did not yield materially different results and is not based on discrete design characteristics that are consistent across all manufacturers.

As explained in the April 2015 NOPR, 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 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, in terms of the comparison between EF and UEF, between atmospheric and direct vent water heaters and also between power and power-direct vent. For these reasons DOE grouped atmospheric and direct into the atmospheric configuration and power and power-direct into the power configuration. Similarly, DOE determined that there was not a significant difference between electronic ignition and standing pilot units and grouped those together for this conversion. 80 FR 20116, 20129–30 (April 14, 2015).

Rheem commented that DOE should test ultra-low-NO_X consumer gas-fired storage water heaters that use a power vent to determine whether a different UEF conversion factor is warranted to differentiate between the different vent types of ultra-low-NO_X water heaters. (Rheem, No. 11 at p. 7) AHRI submitted test data for 17 ultra-low-NO_X consumer gas-fired water heaters: 9 that are atmospherically vented and 8 that are power vented. DOE analyzed separating the ultra-low-NO_X consumer gas-fired storage category into atmospherically vented and power vented categories, and found that the RMSD value decreased by less than 0.001 when separated. DOE tentatively considers a change in RMSD to be negligible if it is less than one unit (0.01 for EF and UEF, 0.1 for maximum GPM, and 1.0 for first-hour rating). DOE has tentatively decided that this decrease is not significant enough to justify a separate conversion, given the additional complexity of separating these products by vent type.

In the April 2015 NOPR, DOE tentatively concluded that tabletop units were not significantly different from electric resistance storage water heaters and considered them together for the purposes of developing the mathematical conversion. 80 FR 20116, 20132 (April 14, 2015). Upon further consideration, DOE believes that tabletop units, due to their efficiency ratings being well below those of traditional electric storage water heaters, may react differently to the UEF test procedure than traditional electric storage water heaters. Therefore, DOE has tentatively decided to propose separate conversions for tabletop and electric resistance water heaters in this SNOPR.

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.

In response to the April 2015 NOPR, Rheem commented generally that DOE did not specify how it determined whether the proposed UEF conversion factors and minimum standards were acceptable and do not effectively amend the energy conservation standards. (Rheem, No. 11 at p. 5) AHRI stated that the tested UEF values do not align with the converted UEF values. (AHRI, No. 13 at p. 4) Regarding the conversion factors, DOE examined multiple approaches and, in most cases, chose the approach that yielded the lowest RMSD value. For certain conversions, DOE chose an approach where the RMSD value was slightly higher, but negligibly so, in favor of a simpler approach to the conversion. (As stated in section III.E.1, DOE tentatively considers a change in RMSD to be negligible if it is less than one unit (0.01 for EF and UEF, 0.1 for maximum GPM, and 1.0 for first-hour rating).) In examining whether the proposed conversion factors are appropriate, DOE considered its certification policies for water heaters contained in 10 CFR part 429. Recognizing the variation in materials, the manufacturing process, and testing, DOE provides bounds on acceptable representations of efficiency for certifying represented values. DOE requires the manufacturer to rate the efficiency of a basic model between the Federal energy conservation standard and up to the lower of the mean of the sample or the 95-percent lower confidence limit divided by 0.9. 10 CFR 429.17. DOE examined the variability between the tested EF and the rated EF for each model tested for this rulemaking by determining the standard deviation for each sample grouping (*i.e.*, the sample data points included for each conversion equation) in order to estimate the amount of variation allowed by DOE's rating requirements at 10 CFR 429.17. DOE then compared the standard deviation of the tested EF values to the RMSD of predicted UEF values.[10] For all product classes, the RMSD of the UEF values was less than or equal to the standard deviation of the EF values when rounded to the nearest 0.01, indicating that the variability of the predicted conversion values is less than or equal to that of the tested EF values observed in a sample of models under the current test procedure. In addition, DOE's approach to ensuring the energy conservation standards are not effectively amended is discussed further in section III.E.3.

NEEA stated that the April 2015 NOPR did not deliver a set of mathematical conversion factors that would enable the marketplace (or anyone else) to rely on the resulting UEF ratings or the proposed UEF standards equations that are derived from those ratings. (NEEA, No. 15 at p. 2) DOE disagrees with NEEA, and believes that the UEF values predicted using the mathematical conversions are reasonable, as evidenced by the resulting RMSD values. RMSD is a measure of the differences between values predicted by a model and those actually observed. As discussed above, the RMSD values for the predicted UEF were less than or equal to the standard deviation of the tested EF values for each class of water heater, suggesting that the mathematical conversion factors presented are reasonably accurate.

a. Consumer Storage Water Heaters

i. Test Results

In total, DOE has conducted testing of 55 consumer storage water heater models using both the EF and UEF test procedures, and likewise, AHRI has supplied test data for 130 consumer storage water heater models using both the EF and UEF test procedures.[11 12] Table III.26 presents the test data used to derive the consumer storage water heater conversion factors. Table III.27 shows the water heater attributes by unit. DOE notes that 1 of the 2 oil-fired storage water heaters, 1 of the 46 electric storage water heaters, and 3 of the 118 gas-fired storage water heaters that were included in the testing and analysis had manufacturer self-declared ratings below the current energy conservation standards (compliance required April 16, 2015). Although the rated efficiency of these water heaters are below the energy conservation standards, DOE believes it is appropriate to use data from these models, because the difference between the relevant parameters under the new and old test procedures (*i.e.*, first-hour rating, EF, and UEF) are likely to be similar to those of a model rated to meet the energy conservation standards. Thus, DOE believes this model is relevant for evaluating the conversion factor which is intended to establish the relationship between ratings under the UEF and EF test procedures. Therefore, DOE has considered these models in its analysis for determining the mathematical conversion factors.

TABLE III.26—CONSUMER STORAGE WATER HEATER TEST DATA

CS No.	AHRI No.	Type	Storage volume (gal)	Input rate (Btu/h)	Prior FHR (gal)	Updated FHR (gal)	Prior recovery efficiency (%)	EF	UEF
1	N/A	Gas	36.8	40,000	73.8	104.2	92.2	0.790	0.802
2	N/A	Gas	45.6	39,800	91.0	85.0	96.2	0.836	0.826
3	N/A	Gas	37.8	39,400	74.5	80.9	80.5	0.692	0.714
4	N/A	Gas	49.4	44,100	97.5	86.7	78.8	0.610	0.634
5	N/A	Gas	38.2	38,300	71.4	64.8	76.4	0.625	0.600
6	N/A	Gas	38.0	40,500	73.5	75.7	83.6	0.702	0.719
7	N/A	Gas	37.9	40,100	80.2	63.8	83.6	0.711	0.669
8	N/A	Gas	47.2	50,600	95.2	87.7	78.3	0.608	0.635
9	N/A	Gas	38.1	39,300	71.9	77.8	75.8	0.607	0.635
10	N/A	Gas	27.8	31,600	59.0	64.4	78.8	0.619	0.605
11	N/A	Gas	38.1	40,200	74.9	70.9	78.5	0.618	0.570
12	N/A	Gas	38.8	32,400	68.7	65.1	77.9	0.664	0.624
13	N/A	Gas	38.4	39,800	70.2	74.1	80.4	0.673	0.654
14	N/A	Gas	27.7	59,600	96.9	94.6	78.2	0.702	0.718

[10] DOE examined RMSD as the measure of the variability between tested and predicted UEF values, as it is a common measure of the accuracy of a model and is often used to compare predicted and measured values. In comparing measured versus rated values for EF, DOE examined standard deviation, which represents the variability of a sample in relation to the mean of that sample. In this case, DOE assumes that the rated EF will represent the mean of the sample. DOE recognizes that under its certification regulation, rated EF may actually be different from the mean of a sample. For purposes of assessing the scope of variability, that difference will not be important.

[11] The AHRI submitted data points 2–5 and 2–6 were not used in this analysis as the reported recovery efficiencies were 98 percent and not calculated from test data.

[12] If multiple tests were conducted on either the same unit or same basic model of a water heater, the results were averaged to produce the values reported in this SNOPR. In one instance within the AHRI-submitted data for consumer storage water heaters, three tests were conducted, where two tests were conducted on the same unit and another test was conducted on a unit of the same basic model. The two tests of the same unit were averaged, and this value was then averaged with the results of the test of the unit of the same basic model.

TABLE III.26—CONSUMER STORAGE WATER HEATER TEST DATA—Continued

CS No.	AHRI No.	Type	Storage volume (gal)	Input rate (Btu/h)	Prior FHR (gal)	Updated FHR (gal)	Prior recovery efficiency (%)	EF	UEF
15	N/A	Gas	38.4	36,300	66.0	68.1	85.0	0.699	0.677
16	N/A	Gas	47.9	49,900	90.2	81.1	81.1	0.674	0.676
17	N/A	Gas	47.8	64,600	108.0	108.8	79.8	0.654	0.680
18	N/A	Gas	38.4	40,000	67.0	81.1	80.5	0.601	0.628
19	N/A	Gas	37.8	39,700	70.2	87.0	80.2	0.610	0.641
20	N/A	Gas	38.1	40,300	68.3	64.8	74.1	0.602	0.598
21	N/A	Gas	28.6	33,000	56.1	70.6	82.2	0.610	0.561
22	N/A	Gas	48.1	36,000	92.1	88.2	80.6	0.630	0.662
23	N/A	Gas	47.7	40,500	94.2	84.0	72.5	0.547	0.640
24	N/A	Gas	26.5	29,500	50.4	51.5	80.8	0.644	0.603
25	N/A	Gas	45.6	39,700	87.9	83.2	77.8	0.593	0.617
26	N/A	Gas	54.1	44,800	103.2	97.9	77.2	0.577	0.596
27	N/A	Oil	30.1	104,000	112.5	127.4	89.4	0.605	0.641
28	N/A	Oil	29.8	105,100	104.8	111.6	71.4	0.518	0.528
29	N/A	Electric	25.7	15,100	41.4	39.7	98.0	0.949	0.903
30	N/A	Electric	25.8	15,400	42.9	42.9	98.0	0.936	0.891
31	N/A	Electric	35.0	15,400	55.5	52.3	98.0	0.941	0.937
32	N/A	Electric	25.1	16,300	40.8	46.2	98.0	0.944	0.902
33	N/A	Electric	36.2	15,200	53.2	50.0	98.0	0.940	0.906
34	N/A	Electric	45.1	15,300	56.5	65.3	98.0	0.930	0.909
35	N/A	Electric	46.0	14,800	66.8	59.9	98.0	0.917	0.932
36	N/A	Electric	46.0	15,400	61.1	59.8	98.0	0.948	0.946
37	N/A	Electric	26.7	13,000	38.7	43.2	98.0	0.912	0.902
38	N/A	Electric	49.7	18,100	68.6	73.3	98.0	0.914	0.942
39	N/A	Electric	35.8	15,000	53.8	48.5	98.0	0.927	0.868
40	N/A	Electric	45.3	15,400	62.7	64.2	98.0	0.922	0.931
41	N/A	Electric	45.2	15,000	66.1	68.7	98.0	0.949	0.919
42	N/A	Electric	36.0	14,900	53.8	54.8	98.0	0.917	0.941
43	N/A	Electric	44.8	14,800	64.9	59.4	98.0	0.958	0.926
44	N/A	Electric	54.5	15,300	80.7	77.2	98.0	0.959	0.952
45	N/A	Electric	45.0	15,200	63.7	56.8	98.0	0.937	0.904
46	N/A	Electric	44.7	15,600	60.7	64.8	98.0	0.915	0.901
47	N/A	Electric	35.9	15,400	52.4	51.9	98.0	0.932	0.922
48	N/A	Tabletop	35.0	15,200	52.9	48.0	98.0	0.877	0.805
49	N/A	Tabletop	25.0	15,400	37.5	45.3	98.0	0.905	0.859
50	N/A	Heat Pump	45.4	15,400	64.5	56.1	282.9	2.486	1.948
51	N/A	Heat Pump	45.5	15,000	57.3	58.9	270.3	2.270	2.572
52	N/A	Heat Pump	45.1	11,100	59.1	48.7	264.7	2.260	2.071
53	N/A	Heat Pump	58.8	15,300	71.5	68.6	296.9	2.280	2.496
54	N/A	Heat Pump	77.5	15,700	90.5	87.1	288.2	2.270	2.642
55	N/A	Heat Pump	80.8	1,800	57.0	58.0	288.0	2.330	2.540
56	1–1	Gas	45.7	39,300	91.6	86.9	91.0	0.789	0.806
57	1–2	Gas	47.9	40,400	89.5	77.3	80.3	0.682	0.704
58	CGS–11	Gas	47.5	40,600	87.5	78.8	83.5	0.697	0.729
59	1–6	Gas	39.0	39,900	65.2	75.6	77.6	0.600	0.653
60	1–11	Gas	28.8	29,600	55.4	52.8	80.2	0.636	0.597
61	1–34	Gas	38.0	39,900	68.5	69.5	82.3	0.649	0.595
62	1–41	Gas	38.2	38,500	70.0	75.9	85.7	0.719	0.750
63	CGS–14	Gas	48.5	40,200	94.9	89.5	82.9	0.625	0.649
64	CGS–19	Gas	27.9	35,400	66.8	67.9	79.9	0.626	0.597
65	CGS–23	Gas	49.3	39,500	89.2	70.0	77.1	0.587	0.560
66	CGS–26	Gas	28.7	30,600	52.5	51.9	77.4	0.612	0.578
67	CGS–32	Gas	38.3	37,400	74.4	70.6	78.7	0.645	0.651
68	CGS–36	Gas	38.6	34,700	74.9	68.0	79.5	0.624	0.574
69	CGS–37	Gas	39.0	38,600	71.3	62.5	81.0	0.622	0.577
70	CGS–38	Gas	28.7	30,600	55.1	59.6	78.8	0.625	0.596
71	CGS–4	Gas	38.7	40,100	64.2	78.8	79.1	0.602	0.637
72	CGS–6	Gas	47.4	50,500	84.9	115.0	78.8	0.580	0.611
73	CGS–8	Gas	48.3	37,600	84.1	78.5	79.5	0.675	0.711
74	1–9	Gas	28.2	59,100	93.0	97.9	80.3	0.688	0.718
75	1–4	Gas	47.9	39,200	88.4	80.7	79.7	0.605	0.656
76	1–7	Gas	47.9	35,300	79.5	69.6	81.8	0.608	0.580
77	1–8	Gas	47.9	40,200	78.0	70.8	79.0	0.596	0.593
78	1–12	Gas	38.2	37,800	75.0	71.5	79.4	0.632	0.558
79	1–13	Gas	48.0	37,700	94.7	87.2	77.6	0.597	0.613
80	1–14	Gas	47.6	37,700	86.3	81.7	75.9	0.575	0.611
81	1–15	Gas	28.0	31,400	57.1	50.6	83.5	0.648	0.598
82	1–17	Gas	47.8	37,900	87.4	81.7	80.8	0.592	0.622
83	1–18	Gas	38.9	37,400	75.4	73.6	81.8	0.633	0.588

TABLE III.26—CONSUMER STORAGE WATER HEATER TEST DATA—Continued

CS No.	AHRI No.	Type	Storage volume (gal)	Input rate (Btu/h)	Prior FHR (gal)	Updated FHR (gal)	Prior recovery efficiency (%)	EF	UEF
84	1–30	Gas	47.8	40,000	83.0	73.0	79.0	0.610	0.580
85	1–33	Gas	48.0	40,000	83.5	67.0	79.0	0.610	0.640
86	CGS–1	Gas	37.8	39,300	67.7	83.8	78.8	0.611	0.654
87	CGS–13	Gas	47.9	36,300	75.6	84.4	78.3	0.588	0.644
88	CGS–15	Gas	54.9	49,600	100.1	89.3	83.5	0.618	0.646
89	CGS–17	Gas	28.8	29,600	51.8	48.2	81.6	0.679	0.603
90	CGS–18	Gas	38.3	33,400	56.1	50.7	82.6	0.633	0.535
91	CGS–2	Gas	47.7	40,300	87.2	80.8	77.7	0.605	0.614
92	CGS–21	Gas	28.7	36,000	67.8	65.1	85.0	0.657	0.620
93	CGS–22	Gas	47.8	39,600	78.2	71.8	80.7	0.615	0.557
94	CGS–24	Gas	38.8	34,500	59.9	59.9	77.4	0.606	0.588
95	CGS–25	Gas	47.6	40,400	84.3	74.6	77.0	0.585	0.556
96	CGS–3	Gas	47.6	40,800	83.1	75.9	83.0	0.634	0.669
97	CGS–30	Gas	28.7	32,100	63.0	55.0	79.7	0.623	0.607
98	CGS–33	Gas	26.6	31,900	52.8	57.8	81.2	0.647	0.623
99	CGS–34	Gas	28.4	29,900	52.3	60.4	83.7	0.630	0.596
100	CGS–39	Gas	38.3	35,500	76.7	72.0	79.1	0.613	0.552
101	CGS–40	Gas	38.4	29,400	59.0	53.7	77.3	0.596	0.556
102	CGS–41	Gas	38.3	37,400	73.7	68.6	81.4	0.634	0.620
103	CGS–5	Gas	48.5	40,100	89.2	82.3	80.5	0.619	0.652
104	CGS–7	Gas	46.1	64,500	103.3	130.2	83.9	0.601	0.646
105	2–1	Gas	28.6	32,000	81.1	67.7	82.5	0.653	0.621
106	2–3	Gas	45.7	64,900	100.0	113.0	82.5	0.624	0.654
107	1–5, 10	Gas	38.4	39,500	65.7	64.9	79.1	0.602	0.571
108	1–35	Gas	46.0	60,000	100.0	113.0	82.5	0.624	0.654
109	1–36	Gas	38.1	39,300	71.8	68.6	81.2	0.688	0.633
110	1–43	Gas	38.1	39,300	69.3	68.6	79.8	0.675	0.646
111	CGS–12	Gas	49.7	39,400	90.6	81.5	81.6	0.699	0.713
112	CGS–31	Gas	38.3	39,700	70.8	66.0	78.0	0.651	0.626
113	CGS–35	Gas	38.2	40,600	69.4	67.3	80.5	0.691	0.662
114	2–2	Gas	48.2	39,800	83.6	81.3	77.5	0.652	0.689
115	1–3	Gas	48.1	41,200	87.9	80.1	75.2	0.640	0.685
116	1–37	Gas	48.1	39,400	86.5	82.9	80.0	0.666	0.646
117	CGS–10	Gas	38.1	37,800	71.7	78.5	82.9	0.697	0.725
118	CGS–16	Gas	47.9	65,700	112.5	114.4	78.3	0.642	0.693
119	CGS–9	Gas	48.6	39,800	92.5	90.7	81.6	0.689	0.704
120	1–22	Gas	39.1	40,100	69.4	87.9	79.3	0.667	0.699
121	1–51	Gas	38.4	38,100	71.2	65.1	79.5	0.614	0.576
122	1–19	Gas	38.2	40,700	77.2	65.8	80.0	0.680	0.658
123	1–21	Gas	48.1	40,400	87.5	82.0	76.6	0.606	0.639
124	1–25	Gas	48.2	39,500	86.6	76.5	79.2	0.590	0.636
125	1–50	Gas	48.1	39,700	91.7	78.6	80.9	0.612	0.636
126	1–47	Gas	38.1	39,600	68.6	77.4	79.7	0.679	0.689
127	1–48	Gas	47.5	61,400	112.0	104.9	82.1	0.683	0.690
128	1–49	Gas	47.5	39,500	85.2	75.9	81.3	0.661	0.674
129	1–20	Gas	47.9	49,700	92.4	86.5	81.7	0.673	0.676
130	1–52	Gas	47.9	44,100	86.9	79.7	81.2	0.682	0.691
131	1–16	Gas	36.8	36,000	67.3	61.6	80.9	0.615	0.592
132	1–44	Gas	48.6	39,200	94.8	91.6	77.4	0.625	0.613
133	1–27, 28, 29	Gas	39.0	35,900	62.6	61.1	79.4	0.625	0.602
134	1–26	Gas	48.1	38,200	83.5	73.9	82.7	0.634	0.592
135	1–45	Gas	38.0	39,300	74.4	75.1	78.3	0.623	0.647
136	CGS–20	Gas	37.8	39,900	75.0	68.4	78.0	0.575	0.529
137	CGS–27	Gas	28.9	30,500	57.0	67.7	79.3	0.628	0.597
138	CGS–28	Gas	38.3	40,700	72.9	66.9	79.3	0.578	0.529
139	CGS–29	Gas	39.4	40,800	72.0	73.5	78.3	0.602	0.580
140	1–40	Gas	38.1	40,700	71.8	68.8	77.1	0.610	0.648
141	1–42	Gas	48.3	39,800	86.0	85.8	80.9	0.673	0.715
142	1–46	Gas	38.3	39,200	71.8	68.1	79.1	0.660	0.633
143	1–23	Gas	38.3	41,600	68.2	84.7	82.6	0.677	0.699
144	1–31	Gas	47.9	42,000	68.0	85.0	82.0	0.680	0.700
145	1–38	Gas	37.8	39,200	87.2	66.5	80.2	0.682	0.560
146	1–39	Gas	46.1	50,000	97.4	92.6	81.8	0.669	0.688
147	1–24, 32	Gas	48.1	42,100	80.2	74.0	87.2	0.710	0.682
148	1–68	Electric	36.1	15,400	53.6	51.2	98.0	0.961	0.942
149	CES–11	Electric	28.6	15,400	42.1	45.9	98.0	0.947	0.897
150	CES–12	Electric	38.4	15,400	49.7	57.4	98.0	0.944	0.922
151	CES–13	Electric	49.8	15,400	63.6	63.3	98.0	0.954	0.911
152	CES–14	Electric	48.6	15,400	59.4	54.3	98.0	0.923	0.920

TABLE III.26—CONSUMER STORAGE WATER HEATER TEST DATA—Continued

CS No.	AHRI No.	Type	Storage volume (gal)	Input rate (Btu/h)	Prior FHR (gal)	Updated FHR (gal)	Prior recovery efficiency (%)	EF	UEF
153	CES–2	Electric	25.8	15,400	41.1	38.6	98.0	0.937	0.897
154	CES–3	Electric	25.6	15,400	43.7	41.4	98.0	0.911	0.890
155	CES–4	Electric	34.7	15,400	52.5	57.3	98.0	0.935	0.938
156	CES–5	Electric	27.7	15,400	46.4	49.1	98.0	0.940	0.898
157	CES–6	Electric	54.7	15,400	80.5	66.4	98.0	0.933	0.933
158	CES–7	Electric	45.2	15,400	66.4	64.2	98.0	0.939	0.912
159	CES–8	Electric	45.2	15,400	63.7	60.7	98.0	0.930	0.910
160	CES–9	Electric	36.1	15,400	54.2	51.5	98.0	0.914	0.888
161	2–4	Electric	39.0	15,400	59.0	55.0	98.0	0.950	0.920
162	2–7	Electric	40.6	15,400	64.9	59.4	98.0	0.960	0.926
163	2–8	Electric	27.3	15,400	45.3	36.5	98.0	0.962	0.878
164	1–64	Electric	36.3	15,400	55.0	52.0	98.0	0.950	0.950
165	1–65	Electric	45.7	15,400	58.0	61.0	98.0	0.940	0.930
166	1–66	Electric	27.1	15,400	48.0	48.0	98.0	0.930	0.870
167	1–53	Electric	45.5	15,400	64.3	60.1	98.0	0.939	0.919
168	1–54	Electric	36.4	15,400	53.9	55.6	98.0	0.932	0.929
169	1–56	Electric	27.4	15,400	47.7	42.1	98.0	0.943	0.911
170	1–57	Electric	36.4	15,400	57.5	51.3	98.0	0.941	0.915
171	1–58	Electric	54.8	15,400	71.0	61.1	98.0	0.936	0.907
172	1–59	Electric	36.2	15,400	59.1	57.0	98.0	0.941	0.931
173	1–69	Electric	45.4	15,400	59.3	58.3	98.0	0.947	0.922
174	1–60, 61, 62	Electric	48.0	15,400	65.3	61.0	98.0	0.940	0.910
175	1–55	Tabletop	36.0	15,400	45.6	58.3	98.0	0.873	0.873
176	1–70	Heat Pump	45.4	15,700	64.5	61.1	289.0	2.450	2.470
177	CES–1	Heat Pump	81.8	15,400	98.4	94.6	304.8	2.617	2.439
178	CES–10	Heat Pump	45.6	15,700	69.3	64.1	369.5	3.278	3.270
179	CES–15	Heat Pump	73.3	16,000	74.9	78.4	249.3	2.297	2.424
180	CES–16	Heat Pump	107.9	16,000	101.7	100.1	214.0	1.971	2.137
181	CES–17	Heat Pump	58.7	16,000	71.3	52.3	246.4	2.291	2.219
182	1–71, 72	Heat Pump	45.5	15,700	69.2	66.1	366.7	3.230	3.140
183	1–76	Heat Pump	75.5	15,700	96.0	89.6	386.5	3.310	3.330
184	1–63, 67	Heat Pump	77.5	15,400	81.8	74.8	262.1	2.242	2.270
185	1–73, 74, 75	Heat Pump	75.5	15,700	95.7	89.4	368.1	3.207	3.186

TABLE III.27—CONSUMER STORAGE WATER HEATER ATTRIBUTES

CS No.	NO_X Emission level	Condensing	Vent type	Short or tall	Standing pilot
1	Low	Yes	Power	Short	No.
2	Low	Yes	Power	Tall	No.
3	Low	No	Atmospheric	Short	No.
4	Low	No	Atmospheric	Short	Yes.
5	Low	No	Atmospheric	Short	Yes.
6	Low	No	Atmospheric	Tall	No.
7	Low	No	Atmospheric	Tall	No.
8	Low	No	Atmospheric	Tall	Yes.
9	Low	No	Atmospheric	Tall	Yes.
10	Low	No	Atmospheric	Tall	Yes.
11	Low	No	Atmospheric	Tall	Yes.
12	Low	No	Power	Short	No.
13	Low	No	Power	Short	No.
14	Low	No	Power	Tall	No.
15	Low	No	Power	Tall	No.
16	Low	No	Power	Tall	No.
17	Low	No	Power	Tall	No.
18	Standard	No	Atmospheric	Short	Yes.
19	Standard	No	Atmospheric	Tall	Yes.
20	Ultra-Low	No	Atmospheric	Short	Yes.
21	Ultra-Low	No	Atmospheric	Tall	Yes.
22	Ultra-Low	No	Atmospheric	Tall	Yes.
23	Ultra-Low	No	Atmospheric	Tall	Yes.
24	Ultra-Low	No	Atmospheric	Tall	Yes.
25	Ultra-Low	No	Atmospheric	Tall	Yes.
26	Ultra-Low	No	Atmospheric	Tall	Yes.
27	N/A	N/A	N/A	Tall	No.
28	N/A	N/A	N/A	Tall	No.
29	N/A	N/A	N/A	Short	N/A.
30	N/A	N/A	N/A	Short	N/A.

TABLE III.27—CONSUMER STORAGE WATER HEATER ATTRIBUTES—Continued

CS No.	NO_X Emission level	Condensing	Vent type	Short or tall	Standing pilot
31	N/A	N/A	N/A	Short	N/A.
32	N/A	N/A	N/A	Short	N/A.
33	N/A	N/A	N/A	Short	N/A.
34	N/A	N/A	N/A	Short	N/A.
35	N/A	N/A	N/A	Short	N/A.
36	N/A	N/A	N/A	Short	N/A.
37	N/A	N/A	N/A	Tall	N/A.
38	N/A	N/A	N/A	Tall	N/A.
39	N/A	N/A	N/A	Tall	N/A.
40	N/A	N/A	N/A	Tall	N/A.
41	N/A	N/A	N/A	Tall	N/A.
42	N/A	N/A	N/A	Tall	N/A.
43	N/A	N/A	N/A	Tall	N/A.
44	N/A	N/A	N/A	Tall	N/A.
45	N/A	N/A	N/A	Tall	N/A.
46	N/A	N/A	N/A	Tall	N/A.
47	N/A	N/A	N/A	Tall	N/A.
48	N/A	N/A	N/A	N/A	N/A.
49	N/A	N/A	N/A	N/A	N/A.
50	N/A	N/A	N/A	N/A	N/A.
51	N/A	N/A	N/A	N/A	N/A.
52	N/A	N/A	N/A	N/A	N/A.
53	N/A	N/A	N/A	N/A	N/A.
54	N/A	N/A	N/A	N/A	N/A.
55	N/A	N/A	N/A	N/A	N/A.
56	Low	Yes	Power	Tall	No.
57	Low	No	Atmospheric	Short	No.
58	Low	No	Atmospheric	Short	No.
59	Low	No	Atmospheric	Short	Yes.
60	Low	No	Atmospheric	Short	Yes.
61	Low	No	Atmospheric	Short	Yes.
62	Low	No	Atmospheric	Short	Yes.
63	Low	No	Atmospheric	Short	Yes.
64	Low	No	Atmospheric	Short	Yes.
65	Low	No	Atmospheric	Short	Yes.
66	Low	No	Atmospheric	Short	Yes.
67	Low	No	Atmospheric	Short	Yes.
68	Low	No	Atmospheric	Short	Yes.
69	Low	No	Atmospheric	Short	Yes.
70	Low	No	Atmospheric	Short	Yes.
71	Low	No	Atmospheric	Short	Yes.
72	Low	No	Atmospheric	Short	Yes.
73	Low	No	Atmospheric	Short	Yes.
74	Low	No	Atmospheric	Tall	No.
75	Low	No	Atmospheric	Tall	Yes.
76	Low	No	Atmospheric	Tall	Yes.
77	Low	No	Atmospheric	Tall	Yes.
78	Low	No	Atmospheric	Tall	Yes.
79	Low	No	Atmospheric	Tall	Yes.
80	Low	No	Atmospheric	Tall	Yes.
81	Low	No	Atmospheric	Tall	Yes.
82	Low	No	Atmospheric	Tall	Yes.
83	Low	No	Atmospheric	Tall	Yes.
84	Low	No	Atmospheric	Tall	Yes.
85	Low	No	Atmospheric	Tall	Yes.
86	Low	No	Atmospheric	Tall	Yes.
87	Low	No	Atmospheric	Tall	Yes.
88	Low	No	Atmospheric	Tall	Yes.
89	Low	No	Atmospheric	Tall	Yes.
90	Low	No	Atmospheric	Tall	Yes.
91	Low	No	Atmospheric	Tall	Yes.
92	Low	No	Atmospheric	Tall	Yes.
93	Low	No	Atmospheric	Tall	Yes.
94	Low	No	Atmospheric	Tall	Yes.
95	Low	No	Atmospheric	Tall	Yes.
96	Low	No	Atmospheric	Tall	Yes.
97	Low	No	Atmospheric	Tall	Yes.
98	Low	No	Atmospheric	Tall	Yes.
99	Low	No	Atmospheric	Tall	Yes.
100	Low	No	Atmospheric	Tall	Yes.
101	Low	No	Atmospheric	Tall	Yes.
102	Low	No	Atmospheric	Tall	Yes.

TABLE III.27—CONSUMER STORAGE WATER HEATER ATTRIBUTES—Continued

CS No.	NO_X Emission level	Condensing	Vent type	Short or tall	Standing pilot
103	Low	No	Atmospheric	Tall	Yes.
104	Low	No	Atmospheric	Tall	Yes.
105	Low	No	Atmospheric	Tall	Yes.
106	Low	No	Atmospheric	Tall	Yes.
107	Low	No	Atmospheric	Tall	Yes.
108	Low	No	Not Specified	Not Specified	Not Specified.
109	Low	No	Power	Short	No.
110	Low	No	Power	Short	No.
111	Low	No	Power	Short	No.
112	Low	No	Power	Short	No.
113	Low	No	Power	Short	No.
114	Low	No	Power	Short	No.
115	Low	No	Power	Tall	No.
116	Low	No	Power	Tall	No.
117	Low	No	Power	Tall	No.
118	Low	No	Power	Tall	No.
119	Low	No	Power	Tall	No.
120	Standard	No	Atmospheric	Short	No.
121	Standard	No	Atmospheric	Short	Yes.
122	Standard	No	Atmospheric	Tall	No.
123	Standard	No	Atmospheric	Tall	Yes.
124	Standard	No	Atmospheric	Tall	Yes.
125	Standard	No	Atmospheric	Tall	Yes.
126	Standard	No	Power	Short	No.
127	Standard	No	Power	Short	No.
128	Standard	No	Power	Short	No.
129	Standard	No	Power	Tall	No.
130	Standard	No	Power	Tall	No.
131	Ultra-Low	No	Atmospheric	Short	Yes.
132	Ultra-Low	No	Atmospheric	Short	Yes.
133	Ultra-Low	No	Atmospheric	Short	Yes.
134	Ultra-Low	No	Atmospheric	Tall	Yes.
135	Ultra-Low	No	Atmospheric	Tall	Yes.
136	Ultra-Low	No	Atmospheric	Tall	Yes.
137	Ultra-Low	No	Atmospheric	Tall	Yes.
138	Ultra-Low	No	Atmospheric	Tall	Yes.
139	Ultra-Low	No	Atmospheric	Tall	Yes.
140	Ultra-Low	No	Power	Short	No.
141	Ultra-Low	No	Power	Short	No.
142	Ultra-Low	No	Power	Short	No.
143	Ultra-Low	No	Power	Tall	No.
144	Ultra-Low	No	Power	Tall	No.
145	Ultra-Low	No	Power	Tall	No.
146	Ultra-Low	No	Power	Tall	No.
147	Ultra-Low	No	Power	Tall	No.
148	N/A	N/A	N/A	Not Specified	N/A.
149	N/A	N/A	N/A	Not Specified	N/A.
150	N/A	N/A	N/A	Not Specified	N/A.
151	N/A	N/A	N/A	Not Specified	N/A.
152	N/A	N/A	N/A	Not Specified	N/A.
153	N/A	N/A	N/A	Not Specified	N/A.
154	N/A	N/A	N/A	Not Specified	N/A.
155	N/A	N/A	N/A	Not Specified	N/A.
156	N/A	N/A	N/A	Not Specified	N/A.
157	N/A	N/A	N/A	Not Specified	N/A.
158	N/A	N/A	N/A	Not Specified	N/A.
159	N/A	N/A	N/A	Not Specified	N/A.
160	N/A	N/A	N/A	Not Specified	N/A.
161	N/A	N/A	N/A	Not Specified	N/A.
162	N/A	N/A	N/A	Not Specified	N/A.
163	N/A	N/A	N/A	Not Specified	N/A.
164	N/A	N/A	N/A	Short	N/A.
165	N/A	N/A	N/A	Short	N/A.
166	N/A	N/A	N/A	Short	N/A.
167	N/A	N/A	N/A	Tall	N/A.
168	N/A	N/A	N/A	Tall	N/A.
169	N/A	N/A	N/A	Tall	N/A.
170	N/A	N/A	N/A	Tall	N/A.
171	N/A	N/A	N/A	Tall	N/A.
172	N/A	N/A	N/A	Tall	N/A.
173	N/A	N/A	N/A	Tall	N/A.
174	N/A	N/A	N/A	Tall	N/A.

TABLE III.27—CONSUMER STORAGE WATER HEATER ATTRIBUTES—Continued

CS No.	NO_X Emission level	Condensing	Vent type	Short or tall	Standing pilot
175	N/A	N/A	N/A	Short	N/A.
176	N/A	N/A	N/A	Not Specified	N/A.
177	N/A	N/A	N/A	Not Specified	N/A.
178	N/A	N/A	N/A	Not Specified	N/A.
179	N/A	N/A	N/A	Not Specified	N/A.
180	N/A	N/A	N/A	Not Specified	N/A.
181	N/A	N/A	N/A	Not Specified	N/A.
182	N/A	N/A	N/A	Not Specified	N/A.
183	N/A	N/A	N/A	Tall	N/A.
184	N/A	N/A	N/A	Tall	N/A.
185	N/A	N/A	N/A	Tall	N/A

ii. Conversion Factor Results

For consumer storage water heaters, DOE is proposing to use the regression method described in section III.C.5 to predict first-hour ratings (FHRs) under the UEF test procedure to be used in the conversion to UEF since no ''analytical approach'' has been developed. Of the factors considered, DOE found that the first-hour rating determined under the EF test procedure was the best overall predictor of the new first-hour rating. These findings were based on the RMSDs between predictions and measured values. The resulting equations, which are proposed for determining the new FHR of consumer storage water heaters, are presented in Table III.28.

TABLE III.28—PROPOSED CONSUMER STORAGE WATER HEATER FIRST-HOUR RATING CONVERSION FACTOR EQUATIONS

Product class	Distinguishing criteria	Conversion factor
Consumer Gas-fired Water Heater	Non-Condensing, Standard or Low NO_X	New FHR = 7.9592 + 0.8752 × FHR_P.
	Non-Condensing, Ultra-Low NO_X	New FHR = 25.0680 + 0.6535 × FHR_P.
	Condensing	New FHR = 1.0570 × FHR_P.
Consumer Oil-fired Water Heater	N/A	New FHR = 1.1012 × FHR_P.
Consumer Electric Water Heater	Electric Resistance	New FHR = 9.2827 + 0.8092 × FHR_P.
	Tabletop	New FHR = 41.5127 + 0.1989 × FHR_P.
	Heat Pump	New FHR = −4.2705 + 0.9947 × FHR_P.

New FHR is the predicted first-hour rating that would result under the UEF test method and is used for conversion to UEF; FHR_P is the first-hour rating determined under the EF test procedure, 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 (condensing gas-fired and oil-fired) the available data were too limited to produce reliable regressions for the full set of parameters. To constrain the regression so as to generate more reliable predictions for those smaller sets of data, the intercepts of the regressions were assigned a value of zero, meaning that a water heater with an FHR_P of zero would also have a New FHR of zero. This assignment is reasonable because if a hypothetical water heater were not able to deliver any water under the EF test procedure, it also would not be able to deliver water under the UEF test procedure.

In response to the first-hour rating mathematical conversion developed in the NOPR, AHRI argued that the results are often inconsistent and show no trend, particularly for the consumer gas-fired storage product class in the medium and high draw patterns. (AHRI, No. 13 at p. 2) Bradford White commented that its testing showed that the FHR for most models went down with the change in test procedure, some of which were affected more than others. (Bradford White, No. 14 at p. 2) NEEA stated that the conversion factors that convert prior FHR ratings to new FHR ratings produce unacceptably large deviations from the measured FHR ratings for a significant majority of the water heaters tested. Further, NEEA commented that these large variations caused 9 of 43 water heaters tested to fall into a different draw bin using the conversion as compared to the tested rating, and it recommended that given the critical nature of the FHR in selecting the proper draw pattern, DOE should not attempt to mathematically derive FHR and maximum GPM ratings, but should instead require them to be measured in accordance with the new test procedures. (NEEA, No. 15 at pp. 5–6)

In response, DOE notes that it explored several possible conversions for developing the FHR conversion. The best trend was observed based on a regression as a function of first-hour rating. The average RMSD value resulting from this approach (7.56 gallons) is the lowest RMSD observed in the FHR analysis, and DOE is unaware of any approaches that would result in improved accuracy. Further, as discussed above in section III.E.2, the predicted UEF values (which are based in part on the predicted FHR values due to the dependence of draw pattern on FHR) are reasonable because they are less than the variability currently allowed in DOE's regulations that manufacturers are required to use and rate their basic models. DOE seeks further comment regarding other methods for predicting FHR that could result in lower RMSDs. In the absence of any known alternatives, DOE plans to continue the use of this methodology, but seeks further comment on other approaches for converting first-hour ratings.

After determining the converted first-hour rating, the next step in the conversion process 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 using 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 1 of the uniform efficiency descriptor test procedure. 10 CFR 430, Subpart B, Appendix E, section 5.4.1. 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.4.c for all consumer water heater types. Alternatively, DOE investigated the step regression approach described in section III.C.2 to convert EF to UEF. As described in the April 2015 NOPR, 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 a conversion with the lowest RMSD observed. 80 FR 20116, 20132 (April 14, 2015). 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 in Table III.30. In light of the additional data compiled for the SNOPR, the RMSD for the non-heat pump storage water heater classes is 0.018 when using a combined WHAM-regression model, and as noted, this is the lowest RMSD observed. DOE, therefore, continues to propose the use of the combined WHAM-regression approach to calculate the conversion factor for all types of consumer storage water heaters except 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. The resulting equations for determining the UEF of consumer storage water heaters are shown in Table III.29.

For heat pump water heaters, DOE determined in the April 2015 NOPR that, although the relevant data can be obtained through testing (and for the units tested by DOE were obtained), the data are not available within the certification databases to compute the WHAM estimate for heat pump water heaters on the market; therefore, a linear regression equation was developed in which the UEF is estimated solely based on the EF. 80 FR 20116, 20132 (April 14, 2015). DOE received no comments submitting data on this point or identifying sources from which DOE could obtain such data. In this SNOPR, DOE proposes that manufacturers should apply the conversions to their test data directly, and then the converted test values will be used to rate the water heater model in accordance with the certification provisions found in 10 CFR 429.17. Because both DOE's data from its testing and the test data submitted by AHRI include all of the necessary information to estimate the efficiency using the WHAM equation, WHAM and WHAM-Regression conversions can be derived based on the tested values. Under either of these approaches, manufacturers would use data from EF tests that is generally not publicly-available (*e.g.*, the recovery efficiency of the heat pump) along with a WHAM-based equation to convert to the UEF metric. The WHAM, regression (modified from the NOPR proposal as discussed immediately below), and WHAM-Regression conversion approaches result in RMSD values of 0.219, 0.194, and 0.197, respectively. The regression approach was modified as discussed below and has the lowest RMSD value, and, therefore, DOE continues to propose to use the regression conversion approach for converting to UEF for HPWH.

GE stated that the proposed conversion for HPWH is inaccurate, and suggested including drawn volume as an independent variable in the regression analysis to improve the conversion for high-EF heat pump water heaters. (GE, No. 12 at p. 1) GE also provided an equation which related EF and drawn volume to UEF. (GE, No. 12 at p. 4) DOE considered these suggestions and agrees that the inclusion of drawn volume as a regression variable would help improve the conversion factor, so DOE has updated the equation appropriately. The GE equation and the new DOE-derived conversion factor results in RMSD values of 0.229 and 0.194, respectively, which is an improvement over the previous conversion factor's RMSD value for heat pump water heaters, which is 0.438 (recalculated with new test data). 80 FR 20116, 20133 (April 14, 2015). Even after considering the large disparity between EF standards and the rated EF values for heat pump water heaters, DOE has nonetheless tentatively concluded that this relatively high RMSD would not cause a water heater to fail to meet the standards based on UEF. Furthermore, the disparity between the UEF of heat pump water heaters and electric resistance water heaters is large enough that consumers would still be made aware of the significant increase in efficiency that heat pump water heaters provide over electric resistance water heaters.

In the equations in Table III.29, UEF_{WHAM} is the conversion factor calculated using the WHAM analytical model, described in section III.C.4.c, EF is the measured energy factor, and DV is the drawn volume in gallons.

TABLE III.29—PROPOSED CONSUMER STORAGE UEF CONVERSION FACTOR EQUATIONS

Product class	Distinguishing criteria	Conversion factor*
Consumer Gas-fired Water Heater	Non-Condensing, Standard or Low NO_X	New UEF = −0.0002 + 0.9858 × UEF_{WHAM}.
	Non-Condensing, Ultra-Low NO_X	New UEF = 0.0746 + 0.8653 × UEF_{WHAM}.
	Condensing	New UEF = 0.4242 + 0.4641 × UEF_{WHAM}.
Consumer Oil-fired Water Heater	N/A	New UEF = −0.0934 + 1.1144 × UEF_{WHAM}.
Consumer Electric Water Heater	Conventional	New UEF = 0.4774 + 0.4740 × UEF_{WHAM}.
	Tabletop	New UEF = −0.3305 + 1.3983 × UEF_{WHAM}.
	Heat Pump	New UEF = 0.1513 + 0.8407 × EF + 0.0043 × DV.

TABLE III.30—CONSUMER STORAGE WATER HEATER CONVERSION FACTOR RESULTS

CS No.	Tested FHR (gal)	Regression FHR (gal)	Tested UEF	WHAM UEF	Regression UEF	WHAM-Regression UEF
1	104.2	78.0	0.802	0.821	0.805	0.805
2	85.0	96.2	0.826	0.865	0.826	0.826
3	80.9	73.2	0.714	0.718	0.685	0.708
4	86.7	93.3	0.634	0.648	0.611	0.638

TABLE III.30—CONSUMER STORAGE WATER HEATER CONVERSION FACTOR RESULTS—Continued

CS No.	Tested FHR (gal)	Regression FHR (gal)	Tested UEF	WHAM UEF	Regression UEF	WHAM-Regression UEF
5	64.8	70.4	0.600	0.607	0.624	0.599
6	75.7	72.3	0.719	0.732	0.694	0.722
7	63.8	78.1	0.669	0.694	0.702	0.684
8	87.7	91.3	0.635	0.645	0.608	0.635
9	77.8	70.9	0.635	0.640	0.608	0.631
10	64.4	59.6	0.605	0.598	0.618	0.589
11	70.9	73.5	0.570	0.598	0.618	0.590
12	65.1	68.1	0.624	0.649	0.660	0.639
13	74.1	69.4	0.654	0.656	0.668	0.647
14	94.6	92.8	0.718	0.721	0.695	0.711
15	68.1	65.7	0.677	0.679	0.691	0.670
16	81.1	86.9	0.676	0.705	0.669	0.694
17	108.8	102.5	0.680	0.686	0.651	0.676
18	81.1	66.6	0.628	0.643	0.602	0.634
19	87.0	69.4	0.641	0.650	0.611	0.641
20	64.8	69.7	0.598	0.584	0.600	0.580
21	70.6	61.7	0.561	0.586	0.607	0.582
22	88.2	85.2	0.662	0.668	0.622	0.652
23	84.0	86.6	0.640	0.584	0.559	0.580
24	51.5	58.0	0.603	0.623	0.632	0.613
25	83.2	82.5	0.617	0.632	0.594	0.622
26	97.9	92.5	0.596	0.617	0.582	0.609
27	127.4	123.8	0.641	0.659	0.641	0.641
28	111.6	115.4	0.528	0.557	0.528	0.528
29	39.7	42.8	0.903	0.926	0.922	0.916
30	42.9	44.0	0.891	0.905	0.912	0.906
31	52.3	54.2	0.937	0.935	0.917	0.921
32	46.2	42.3	0.902	0.919	0.919	0.913
33	50.0	52.3	0.906	0.912	0.916	0.910
34	65.3	55.0	0.909	0.922	0.908	0.914
35	59.9	63.3	0.932	0.906	0.898	0.907
36	59.8	58.7	0.946	0.943	0.922	0.924
37	43.2	40.6	0.902	0.866	0.894	0.888
38	73.3	64.8	0.942	0.903	0.895	0.906
39	48.5	52.8	0.868	0.891	0.906	0.900
40	64.2	60.0	0.931	0.912	0.902	0.910
41	68.7	62.8	0.919	0.944	0.923	0.925
42	54.8	52.8	0.941	0.906	0.898	0.907
43	59.4	61.8	0.926	0.955	0.930	0.930
44	77.2	74.6	0.952	0.965	0.930	0.935
45	56.8	60.9	0.904	0.930	0.913	0.918
46	64.8	58.4	0.901	0.905	0.897	0.906
47	51.9	51.7	0.922	0.923	0.909	0.915
48	48.0	52.0	0.805	0.812	0.867	0.805
49	45.3	49.0	0.859	0.855	0.888	0.865
50	56.1	59.9	1.948	2.441	2.478	2.494
51	58.9	52.7	2.572	2.215	2.296	2.312
52	48.7	54.5	2.071	2.049	2.214	2.177
53	68.6	66.8	2.496	2.202	2.305	2.301
54	87.1	85.7	2.642	2.401	2.421	2.462
55	58.0	52.4	2.540	2.213	2.347	2.310
56	86.9	96.8	0.806	0.817	0.804	0.803
57	77.3	86.3	0.704	0.710	0.676	0.699
58	78.8	84.5	0.729	0.728	0.690	0.718
59	75.6	65.0	0.653	0.637	0.601	0.628
60	52.8	56.4	0.597	0.615	0.634	0.606
61	69.5	67.9	0.595	0.628	0.646	0.619
62	75.9	69.2	0.750	0.750	0.710	0.739
63	89.5	91.0	0.649	0.667	0.624	0.658
64	67.9	66.4	0.597	0.605	0.625	0.596
65	70.0	86.0	0.560	0.566	0.590	0.557
66	51.9	53.9	0.578	0.592	0.612	0.583
67	70.6	73.1	0.651	0.627	0.642	0.618
68	68.0	73.5	0.574	0.603	0.623	0.594
69	62.5	70.4	0.577	0.600	0.622	0.591
70	59.6	56.2	0.596	0.605	0.624	0.596
71	78.8	64.1	0.637	0.642	0.603	0.632
72	115.0	82.3	0.611	0.622	0.583	0.613
73	78.5	81.6	0.711	0.702	0.670	0.692
74	97.9	89.4	0.718	0.714	0.682	0.704

TABLE III.30—CONSUMER STORAGE WATER HEATER CONVERSION FACTOR RESULTS—Continued

CS No.	Tested FHR (gal)	Regression FHR (gal)	Tested UEF	WHAM UEF	Regression UEF	WHAM-Regression UEF
75	80.7	85.3	0.656	0.645	0.606	0.636
76	69.6	77.5	0.580	0.584	0.609	0.576
77	70.8	76.2	0.593	0.574	0.598	0.565
78	71.5	73.6	0.558	0.612	0.631	0.603
79	87.2	90.8	0.613	0.635	0.599	0.626
80	81.7	83.5	0.611	0.614	0.579	0.605
81	50.6	57.9	0.598	0.625	0.645	0.616
82	81.7	84.5	0.622	0.636	0.594	0.627
83	73.6	73.9	0.588	0.611	0.632	0.602
84	73.0	80.6	0.580	0.589	0.611	0.580
85	67.0	81.0	0.640	0.589	0.611	0.580
86	83.8	67.2	0.654	0.649	0.611	0.639
87	84.4	74.1	0.644	0.629	0.590	0.620
88	89.3	95.6	0.646	0.662	0.618	0.653
89	48.2	53.3	0.603	0.606	0.674	0.598
90	50.7	57.1	0.535	0.544	0.632	0.536
91	80.8	84.3	0.614	0.642	0.606	0.632
92	65.1	67.3	0.620	0.634	0.653	0.625
93	71.8	76.4	0.557	0.593	0.615	0.584
94	59.9	60.4	0.588	0.586	0.607	0.577
95	74.6	81.7	0.556	0.564	0.588	0.555
96	75.9	80.7	0.669	0.675	0.632	0.665
97	55.0	63.1	0.607	0.602	0.622	0.593
98	57.8	54.2	0.623	0.626	0.644	0.617
99	60.4	53.7	0.596	0.606	0.629	0.597
100	72.0	75.1	0.552	0.592	0.613	0.583
101	53.7	59.6	0.556	0.574	0.598	0.566
102	68.6	72.5	0.620	0.613	0.632	0.604
103	82.3	86.0	0.652	0.658	0.619	0.649
104	130.2	98.4	0.646	0.648	0.602	0.639
105	67.7	78.9	0.621	0.632	0.650	0.623
106	113.0	95.5	0.654	0.666	0.623	0.656
107	64.9	65.5	0.571	0.580	0.603	0.571
108	113.0	95.5	0.654	0.666	0.623	0.656
109	68.6	70.8	0.633	0.672	0.682	0.662
110	68.6	68.6	0.646	0.659	0.670	0.649
111	81.5	87.3	0.713	0.726	0.692	0.715
112	66.0	69.9	0.626	0.634	0.648	0.625
113	67.3	68.7	0.662	0.676	0.684	0.666
114	81.3	81.1	0.689	0.680	0.649	0.670
115	80.1	84.9	0.685	0.666	0.638	0.656
116	82.9	83.7	0.646	0.696	0.662	0.686
117	78.5	70.7	0.725	0.727	0.690	0.716
118	114.4	106.4	0.693	0.673	0.640	0.663
119	90.7	88.9	0.704	0.718	0.683	0.707
120	87.9	68.7	0.699	0.695	0.663	0.685
121	65.1	70.3	0.576	0.593	0.614	0.584
122	65.8	75.5	0.658	0.664	0.674	0.655
123	82.0	84.5	0.639	0.641	0.607	0.631
124	76.5	83.8	0.636	0.632	0.592	0.623
125	78.6	88.2	0.636	0.653	0.612	0.644
126	77.4	68.0	0.689	0.706	0.674	0.696
127	104.9	106.0	0.690	0.714	0.677	0.703
128	75.9	82.5	0.674	0.695	0.657	0.685
129	86.5	88.8	0.676	0.705	0.668	0.695
130	79.7	84.0	0.691	0.711	0.676	0.701
131	61.6	69.0	0.592	0.592	0.610	0.587
132	91.6	87.0	0.613	0.658	0.618	0.644
133	61.1	66.0	0.602	0.605	0.618	0.598
134	73.9	79.6	0.592	0.611	0.625	0.604
135	75.1	73.7	0.647	0.658	0.616	0.644
136	68.4	74.1	0.529	0.552	0.580	0.552
137	67.7	62.3	0.597	0.607	0.620	0.600
138	66.9	72.7	0.529	0.554	0.582	0.554
139	73.5	72.1	0.580	0.581	0.601	0.577
140	68.8	72.0	0.648	0.591	0.607	0.586
141	85.8	81.3	0.715	0.704	0.654	0.683
142	68.1	72.0	0.633	0.643	0.644	0.631
143	84.7	69.6	0.699	0.710	0.657	0.689
144	85.0	69.5	0.700	0.711	0.660	0.690

TABLE III.30—CONSUMER STORAGE WATER HEATER CONVERSION FACTOR RESULTS—Continued

CS No.	Tested FHR (gal)	Regression FHR (gal)	Tested UEF	WHAM UEF	Regression UEF	WHAM-Regression UEF
145	66.5	82.1	0.560	0.666	0.661	0.651
146	92.6	88.7	0.688	0.702	0.651	0.682
147	74.0	77.4	0.682	0.690	0.682	0.672
148	51.2	52.7	0.942	0.957	0.932	0.931
149	45.9	43.4	0.897	0.924	0.921	0.915
150	57.4	49.5	0.922	0.938	0.919	0.922
151	63.3	60.7	0.911	0.950	0.926	0.927
152	54.3	57.3	0.920	0.914	0.903	0.910
153	38.6	42.5	0.897	0.907	0.913	0.907
154	41.4	44.6	0.890	0.865	0.893	0.887
155	57.3	51.8	0.938	0.927	0.912	0.917
156	49.1	46.8	0.898	0.912	0.916	0.910
157	66.4	74.4	0.933	0.925	0.910	0.916
158	64.2	63.0	0.912	0.932	0.915	0.919
159	60.7	60.8	0.910	0.922	0.908	0.914
160	51.5	53.1	0.888	0.903	0.896	0.905
161	55.0	57.0	0.920	0.945	0.923	0.925
162	59.4	61.8	0.926	0.957	0.931	0.931
163	36.5	45.9	0.878	0.949	0.933	0.927
164	52.0	53.8	0.950	0.945	0.923	0.925
165	61.0	56.2	0.930	0.933	0.916	0.920
166	48.0	48.1	0.870	0.896	0.908	0.902
167	60.1	61.3	0.919	0.932	0.915	0.919
168	55.6	52.9	0.929	0.924	0.909	0.915
169	42.1	47.8	0.911	0.917	0.918	0.912
170	51.3	55.8	0.915	0.934	0.916	0.920
171	61.1	66.7	0.907	0.929	0.913	0.918
172	57.0	57.1	0.931	0.934	0.916	0.920
173	58.3	57.3	0.922	0.941	0.921	0.924
174	61.0	62.1	0.910	0.933	0.916	0.920
175	58.3	50.6	0.873	0.856	0.864	0.867
176	61.1	59.9	2.470	2.394	2.448	2.456
177	94.6	93.6	2.439	2.715	2.713	2.716
178	64.1	64.7	3.270	3.223	3.144	3.127
179	78.4	70.2	2.424	2.344	2.444	2.416
180	100.1	96.9	2.137	2.012	2.170	2.147
181	52.3	66.7	2.219	2.266	2.314	2.353
182	66.1	64.5	3.140	3.173	3.103	3.087
183	89.6	91.2	3.330	3.436	3.295	3.299
184	74.8	77.0	2.270	2.193	2.272	2.293
185	89.4	91.0	3.186	3.316	3.208	3.202

In response to the UEF conversion for the NOPR, AHRI commented that units tested with the very small, low, and medium draw patterns will likely have UEF values less than EF, while units tested with the high draw pattern will likely have UEF values greater than EF due to standby times. (AHRI, No. 13 at p. 6) Were standby time the only factor affecting the difference between EF and UEF, AHRI's argument would have some merit. However, in 9 percent of the consumer storage tests, a pattern opposite from what AHRI suggested was observed. This empirical observation indicates that AHRI's assumptions are not wholly correct. AHRI also commented that for most of the electric resistance water heater samples, the calculated conversion factor using the WHAM-regression UEF model does not track with the tested UEF (*i.e.*, some values are higher than the test result, others lower). (AHRI, No. 13 at p. 5) Further, AHRI stated that for electric resistance models, the measured UEF is consistently lower than the measured EF, although the amount of difference varies. AHRI stated that the data for units in the low-usage bin indicate a very significant miscalculation of the effect of the UEF test procedure on those models, and that the converted UEF value in most cases is higher than the measured UEF value, which suggests that the converted UEF formula is underestimating the effect of the uniform energy descriptor test procedure. (AHRI, No. 6 at p. 2) AHRI also pointed out that the measured UEFs for low-input (<10,000 Btu/h) heat pump water heaters were higher than the measured EF, and for the one higher-input unit, the measured UEF was lower than the measured EF. However, with one exception, the calculated UEF using the proposed conversion exhibited the opposite results. (AHRI, No. 13 at p. 5)

Rheem commented that several electric storage water heaters (both heat pump and non-heat pump) in the medium draw pattern show an increased UEF rating as compared to EF in DOE's test results. However, Rheem asserted that since the UEF test method has more standby time than the EF test method, the resulting UEF would be expected to decrease, and stated that it has observed a consistent decrease in the UEF of electric storage water heaters in the medium draw bin, as compared to the EF rating. (Rheem, No. 11 at pp. 4–5)

With respect to AHRI's observation that the WHAM-regression model does not perfectly reproduce the UEF measurements of every model, DOE notes that, as discussed previously, a simple conversion formula will not reproduce identically the results that one would measure by applying the EF and UEF test methods for each and every unit. Yet DOE's task, as required by the statute, is to prepare a set of conversion formulas. DOE understands the statute, by implication, to contemplate that for any given unit, there may be some difference between the formula output and the comparative EF and UEF test results.

AHRI's observation that the measured UEF is consistently less than the measured EF for electric resistance storage water heaters in the low-draw bin generally still holds for the conversion factor proposed in this SNOPR, and as stated above, this behavior is expected. Of the 13 low-draw-pattern units for which test data are available for the SNOPR, the conversion factor predicts a UEF higher than the tested UEF in 9 cases, equal to the tested UEF in 3 cases, and lower than the predicted UEF in 1 case. DOE reasons that this result is due to the large number of medium-draw-pattern units used to derive the conversion factor. Similarly, the converted UEF for the one high-draw-pattern electric storage water heater is below the tested UEF value. Because the regression analysis is conducted across all draw patterns for a given class, the result may more heavily favor draw patterns with more data present. DOE believes that proposing a separate conversion for each draw pattern would eliminate this issue. However, if DOE were to propose conversions for each draw pattern, the number of UEF conversion equations would increase from 26 to 104. DOE believes a separate conversion factor for each draw pattern would add a significant amount of complexity to the conversion factor that would not be justified by the slight skew toward draw patterns with more units (and therefore more test data). DOE also notes that the converted values are not always higher than the tested values under the conversions proposed in this SNOPR indicating that this effect does not occur consistently for all units. Further, Rheem's observation that the consumer electric storage medium-draw-pattern testing yields UEFs greater than corresponding EF values for some units appears to occur in both the DOE and AHRI data sets, suggesting that standby time is not the only variable to consider when comparing results from the two test procedures. AHRI's observation about the effect of the input rate on the difference between measured UEF and EF in the heat pump water heater tests based on the NOPR data appears not to hold with the addition of the AHRI test data.

For gas-fired storage water heaters, AHRI commented that in the medium-usage bin, the measured UEF is consistently lower than the measured EF, but there is no consistent pattern in the difference between the measured UEF and the converted UEF. (AHRI, No. 6 at p. 2) For gas-fired storage water heaters in the high-usage bin, AHRI stated that the measured UEF is consistently higher than the measured EF, and there is no consistent relationship between the converted UEF value and the measured UEF value. (AHRI, No. 6 at p. 2) AHRI and Rheem commented that, for ultra-low NO_X gas-fired water heaters, the measured UEF for the short models was less than the measured EF and the measured UEF for the tall models was greater than the measured EF, but that the calculated UEF using the conversion exhibits the opposite relationship. AHRI and Rheem suggested the trend requires further test data for such units. (AHRI, No. 13 at p. 5; Rheem, No. 11 at p. 7)

In general, measured UEF values in the very small, low, or medium draw patterns will usually be lower than their respective measured EF values, and measured UEF values in the high draw patterns will usually be higher than their respective measured EF value. Also, this outcome (*i.e.*, converted results both higher and lower than the measured results for a category of water heater) is what one should expect if the conversion is, overall, a reasonable representation of efficiency. Therefore, AHRI's comments about the consumer gas-fired storage test and conversion data for the medium and high draw pattern reflect the expected result of the conversion.

AHRI and Rheem's comment about the ultra-low NO_X short comparison of measured EF and UEF seems to still hold with the addition of the AHRI test data; that is, the measured UEF for 4 of the 7 short models was less than the measured EF, equal to the measured EF for 1 unit, and greater than the measured EF for 2 units. The measured UEF for the tall models was greater than the measured EF in 8 of the 17 units, and less than the measured EF in the other 9 units. When examining the converted UEF values, 5 short units have converted UEFs less than the measured EF and 2 that are greater, while the same relationship exists in the converted UEF data as was observed in the measured UEF data for the tall units. Further, deriving separate conversions for short and tall ultra-low NO_X water heaters decreases the RMSD value by less than 0.0015, which seems like a negligible improvement when weighed against the added complexity of an additional conversion factor. DOE also notes that it is not aware of an industry-accepted consensus for determining whether a water heater is ''tall'' or ''short,'' which makes implementing a conversion based on this factor difficult.

b. Consumer Instantaneous Water Heaters

i. Test Results

DOE has tested 22 consumer instantaneous water heaters to both the EF and UEF test procedures, and AHRI has supplied test data for 36 additional units of this water heater type.[13] [14] Table III.31 presents the test data used to derive the proposed consumer instantaneous water heater conversion factors. DOE notes that 1 of the 53 gas-fired instantaneous water heaters that were tested is not rated to meet the current energy conservation standards (compliance required April 16, 2015). However, as discussed in section III.E.2.a.i, DOE believes that these data points are valid for the purpose of determining the mathematical 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.32 shows the water heater attributes by unit described in section III.E.1.

[13] The AHRI submitted test data point CIS–5 was not used because the measured input rate was greater than the maximum allowable deviation from the rated input rate of 2 percent, resulting in an invalid test.

[14] If multiple tests were conducted on either the same unit or same basic model of a water heater, the results were averaged to produce the values reported in this SNOPR. In one instance within the AHRI submitted data for consumer instantaneous water heaters, three tests were conducted, where two tests were conducted on the same unit and another test was conducted on a unit of the same basic model. The two tests of the same unit were averaged and this value was then averaged with the results of the test of the unit of the same basic model.

TABLE III.31—CONSUMER INSTANTANEOUS WATER HEATER TEST DATA

CI No.	AHRI No.	Type	Input rate (Btu/h)	Prior max GPM	Updated max GPM	Prior recovery efficiency (%)	EF	UEF
1	N/A.	Gas	142,500	3.0	3.4	80.9	0.801	0.800
2	N/A.	Gas	190,800	4.2	4.8	81.4	0.813	0.820
3	N/A.	Gas	120,900	2.7	3.1	82.6	0.828	0.809
4	N/A.	Gas	141,100	3.1	3.6	81.7	0.812	0.823
5	N/A.	Gas	175,800	3.7	4.3	84.5	0.838	0.833
6	N/A.	Gas	178,500	4.1	4.7	83.8	0.838	0.830
7	N/A.	Gas	199,000	4.6	4.9	86.9	0.872	0.841
8	N/A.	Gas	179,900	4.0	4.6	80.3	0.803	0.840
9	N/A.	Gas	180,400	3.9	4.6	85.1	0.852	0.832
10	N/A.	Gas	199,200	4.3	5.1	75.0	0.743	0.799
11	N/A.	Gas	151,700	3.4	3.9	85.4	0.853	0.813
12	N/A.	Gas	199,800	4.8	4.1	93.8	0.932	0.939
13	N/A.	Gas	197,200	5.2	5.8	96.7	0.966	0.958
14	N/A.	Gas	154,100	4.0	4.5	91.6	0.913	0.925
15	N/A.	Gas	201,300	4.9	5.7	88.0	0.851	0.884
16	N/A.	Gas	117,800	2.5	2.9	77.7	0.776	0.757
17	N/A.	Gas	148,800	3.3	3.7	82.6	0.823	0.811
18	N/A.	Electric	33,100	0.9	1.0	101.7	1.018	1.010
19	N/A.	Electric	7,800	0.2	0.2	101.2	1.013	0.983
20	N/A.	Electric	19,800	0.5	0.6	102.2	1.020	1.006
21	N/A.	Electric	26,000	0.7	0.8	102.0	1.019	1.007
22	N/A.	Electric	31,000	0.8	0.9	101.5	1.017	0.982
23	1–94	Gas	187,800	4.0	4.5	80.2	0.794	0.809
24	1–92, 93	Gas	187,900	4.0	4.4	83.0	0.816	0.815
25	CIS–1	Gas	137,700	3.1	3.6	83.6	0.832	0.812
26	CIS–2	Gas	198,300	4.3	5.0	85.0	0.845	0.843
27	CIS–3	Gas	151,600	3.4	3.9	84.8	0.845	0.806
28	CIS–4	Gas	202,100	4.4	5.1	91.7	0.916	0.869
29	CIS–6	Gas	148,400	3.2	3.8	83.4	0.836	0.805
30	CIS–9	Gas	196,000	4.4	5.0	88.7	0.882	0.869
31	1–85	Gas	202,300	4.4	5.1	86.3	0.864	0.817
32	1–86	Gas	200,400	4.4	5.1	86.3	0.859	0.826
33	1–87	Gas	186,500	4.3	4.8	83.9	0.838	0.816
34	1–88	Gas	195,700	4.3	5.0	80.8	0.809	0.640
35	1–89	Gas	142,900	3.2	3.6	84.6	0.842	0.792
36	1–90	Gas	188,500	4.0	4.6	85.3	0.847	0.824
37	1–100	Gas	197,400	4.3	5.5	83.8	0.826	0.818
38	1–101	Gas	141,800	3.1	3.6	83.1	0.831	0.816
39	1–77, 83, 84.	Gas	151,600	3.5	4.0	87.2	0.874	0.851
40	1–97	Gas	198,700	4.8	5.5	98.8	0.975	0.952
41	CIS–7	Gas	195,100	5.1	5.6	97.8	0.978	0.922
42	CIS–8	Gas	150,100	3.7	4.3	95.3	0.951	0.918
43	2–9	Gas	203,200	4.8	5.5	98.2	0.974	0.943
44	2–10	Gas	177,200	4.4	5.0	96.8	0.951	0.925
45	2–11	Gas	203,500	4.9	5.4	98.1	0.974	0.945
46	2–12	Gas	195,100	4.9	5.6	96.7	0.965	0.922
47	2–13	Gas	150,100	3.7	4.3	95.3	0.951	0.918
48	1–78	Gas	155,000	3.8	4.4	97.4	0.964	0.928
49	1–79	Gas	159,400	4.0	4.5	96.1	0.959	0.921
50	1–80	Gas	176,900	4.3	4.9	96.3	0.947	0.920
51	1–81	Gas	176,700	4.3	4.9	97.9	0.966	0.933
52	1–82	Gas	183,200	4.5	5.2	96.5	0.957	0.919
53	1–91	Gas	120,500	3.1	3.5	94.1	0.937	0.910
54	1–98	Gas	182,100	4.1	5.1	90.8	0.908	0.911
55	1–99	Gas	197,000	5.0	5.0	95.3	0.935	0.924
56	1–102	Gas	122,300	2.9	3.4	91.4	0.915	0.883
57	1–103	Gas	183,000	4.4	4.8	92.1	0.914	0.901
58	1–104	Gas	121,100	2.7	3.2	91.5	0.910	0.864

TABLE III.32—CONSUMER INSTANTANEOUS WATER HEATER ATTRIBUTES

CI No.	NO_X emission level	Condensing
1	Low	No.
2	Low	No.
3	Low	No.
4	Low	No.
5	Ultra-Low	No.
6	Ultra-Low	No.
7	Ultra-Low	No.

TABLE III.32—CONSUMER INSTANTANEOUS WATER HEATER ATTRIBUTES—Continued

CI No.	NO_X emission level	Condensing
8	Ultra-Low	No.
9	Ultra-Low	No.
10	Ultra-Low	No.
11	Ultra-Low	No.
12	Ultra-Low	Yes.
13	Ultra-Low	Yes.
14	Ultra-Low	Yes.
15	Ultra-Low	Yes.
16	Low	No.
17	Low	No.
18	N/A.	N/A.
19	N/A.	N/A.
20	N/A.	N/A.
21	N/A.	N/A.
22	N/A.	N/A.
23	Low	No.
24	Low	No.
25	Ultra-Low	No.
26	Ultra-Low	No.
27	Ultra-Low	No.
28	Ultra-Low	No.
29	Ultra-Low	No.
30	Ultra-Low	No.
31	Ultra-Low	No.
32	Ultra-Low	No.
33	Ultra-Low	No.
34	Ultra-Low	No.
35	Ultra-Low	No.
36	Ultra-Low	No.
37	Ultra-Low	No.
38	Ultra-Low	No.
39	Ultra-Low	No.
40	Low	Yes.
41	Ultra-Low	Yes.
42	Ultra-Low	Yes.
43	Ultra-Low	Yes.
44	Ultra-Low	Yes.
45	Ultra-Low	Yes.
46	Ultra-Low	Yes.
47	Ultra-Low	Yes.

TABLE III.32—CONSUMER INSTANTANEOUS WATER HEATER ATTRIBUTES—Continued

CI No.	NO_X emission level	Condensing
48	Ultra-Low	Yes.
49	Ultra-Low	Yes.
50	Ultra-Low	Yes.
51	Ultra-Low	Yes.
52	Ultra-Low	Yes.
53	Ultra-Low	Yes.
54	Ultra-Low	Yes.
55	Ultra-Low	Yes.
56	Ultra-Low	Yes.
57	Ultra-Low	Yes.
58	Ultra-Low	Yes.

ii. Conversion Factor Results

As stated in section III.C.4.a, DOE developed an analytical model that DOE proposes to use to convert the prior measured values of maximum GPM rating for consumer instantaneous water heaters to measured values under the uniform efficiency descriptor test procedure. DOE also developed an analytical method to estimate the change in prior measured values of energy factor under the energy factor test procedure to measured values of uniform energy factor 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.34. For the maximum GPM conversions, the RMSD for the three approaches are 0.24, 0.23, and 0.23, respectively. For the UEF conversions, the three approaches have RMSD of 0.035, 0.028, and 0.027, respectively. DOE has decided to continue to propose to use the analytical model approach to calculate the consumer instantaneous maximum GPM conversion factor owing to the fact that the analytical model approach predicts the resultant data very closely and that it will broadly apply to those units not tested. DOE has also decided to continue to propose to use the combined analytical model-regression approach to convert from EF to UEF since the RMSDs are the lowest observed, and it has concluded that the use of the model and regression will capture key effects that may not be captured with either approach by itself. The resulting conversion factors for both maximum GPM and UEF are shown in Table III.33. In the equations in Table III.33, Max GPM_P is the maximum GPM based on the prior DOE test procedure and UEF_{model} is the predicted UEF determined using the analytical model, described in section III.C.4.c.

TABLE III.33—PROPOSED CONSUMER INSTANTANEOUS CONVERSION FACTOR EQUATIONS

Product class	Conversion factor
All Consumer Instantaneous.	New Max GPM = 1.1461 x Max GPM_P
Gas-fired Instantaneous.	New UEF = 0.1006 + 0.8622 × UEF_{model}
Electric Instantaneous.	New UEF = 0.9847 × UEF_{model}

TABLE III.34—CONSUMER INSTANTANEOUS CONVERSION FACTOR RESULTS

CI No.	Tested max GPM	Analytical max GPM	Regression max GPM	Combined Analytical-Regression Max GPM	Tested UEF	Analytical UEF	Regression UEF	Combined Analytical-Regression UEF
1	3.44	3.39	3.49	3.49	0.800	0.804	0.791	0.794
2	4.81	4.85	4.80	4.80	0.820	0.810	0.802	0.799
3	3.11	3.09	3.21	3.21	0.809	0.820	0.814	0.808
4	3.61	3.57	3.64	3.64	0.823	0.811	0.801	0.800
5	4.31	4.21	4.22	4.22	0.833	0.841	0.823	0.825
6	4.71	4.68	4.64	4.64	0.830	0.834	0.823	0.820
7	4.87	5.29	5.18	5.18	0.841	0.865	0.852	0.846
8	4.59	4.60	4.57	4.57	0.840	0.799	0.793	0.790
9	4.61	4.50	4.48	4.48	0.832	0.847	0.835	0.831
10	5.07	4.93	4.86	4.86	0.799	0.747	0.741	0.745
11	3.89	3.85	3.90	3.90	0.813	0.847	0.836	0.831
12	4.11	5.50	5.37	5.37	0.939	0.933	0.904	0.905
13	5.81	5.94	5.77	5.77	0.958	0.962	0.934	0.930
14	4.48	4.56	4.53	4.53	0.925	0.912	0.888	0.887
15	5.70	5.62	5.48	5.48	0.884	0.876	0.834	0.856
16	2.88	2.85	3.01	3.01	0.757	0.772	0.770	0.766
17	3.67	3.73	3.79	3.79	0.811	0.821	0.810	0.808
18	0.99	1.00	1.00	1.00	1.010	1.013	1.000	0.997
19	0.24	0.24	0.24	0.24	0.983	1.008	0.981	0.993
20	0.60	0.59	0.60	0.60	1.006	1.018	1.007	1.003
21	0.80	0.78	0.78	0.78	1.007	1.016	1.003	1.001

TABLE III.34—CONSUMER INSTANTANEOUS CONVERSION FACTOR RESULTS—Continued

CI No.	Tested max GPM	Analytical max GPM	Regression max GPM	Combined Analytical-Regression Max GPM	Tested UEF	Analytical UEF	Regression UEF	Combined Analytical-Regression UEF
22	0.93	0.94	0.94	0.94	0.982	1.011	0.997	0.996
23	4.50	4.61	4.57	4.57	0.809	0.798	0.785	0.789
24	4.40	4.57	4.54	4.54	0.815	0.826	0.804	0.813
25	3.56	3.55	3.63	3.63	0.812	0.830	0.818	0.817
26	4.95	4.97	4.90	4.90	0.843	0.846	0.829	0.830
27	3.94	3.93	3.97	3.97	0.806	0.842	0.829	0.827
28	5.10	5.00	4.92	4.92	0.869	0.913	0.890	0.888
29	3.80	3.67	3.73	3.73	0.805	0.828	0.821	0.814
30	5.05	4.99	4.91	4.91	0.869	0.883	0.861	0.862
31	5.14	5.06	4.98	4.98	0.817	0.859	0.845	0.841
32	5.07	5.01	4.93	4.93	0.826	0.859	0.841	0.841
33	4.84	4.92	4.85	4.85	0.816	0.835	0.823	0.821
34	4.96	4.93	4.86	4.86	0.640	0.804	0.798	0.794
35	3.63	3.64	3.71	3.71	0.792	0.840	0.827	0.825
36	4.57	4.63	4.59	4.59	0.824	0.849	0.831	0.833
37	5.52	4.93	4.86	4.86	0.818	0.834	0.813	0.820
38	3.62	3.50	3.58	3.58	0.816	0.825	0.817	0.812
39	4.00	3.96	4.00	4.00	0.851	0.868	0.855	0.849
40	5.54	5.47	5.34	5.34	0.952	0.983	0.941	0.948
41	5.60	5.85	5.68	5.68	0.922	0.973	0.944	0.939
42	4.30	4.24	4.25	4.25	0.918	0.948	0.921	0.918
43	5.50	5.50	5.37	5.37	0.943	0.977	0.941	0.943
44	5.00	5.04	4.96	4.96	0.925	0.963	0.921	0.931
45	5.40	5.62	5.48	5.48	0.945	0.976	0.941	0.942
46	5.60	5.62	5.48	5.48	0.922	0.962	0.933	0.930
47	4.30	4.24	4.25	4.25	0.918	0.948	0.921	0.918
48	4.36	4.34	4.34	4.34	0.928	0.969	0.932	0.936
49	4.52	4.54	4.51	4.51	0.921	0.956	0.928	0.925
50	4.94	4.92	4.85	4.85	0.920	0.958	0.917	0.926
51	4.92	4.91	4.84	4.84	0.933	0.974	0.934	0.940
52	5.18	5.20	5.11	5.11	0.919	0.960	0.926	0.928
53	3.50	3.54	3.62	3.62	0.910	0.934	0.909	0.906
54	5.10	4.74	4.70	4.70	0.911	0.904	0.884	0.880
55	5.05	5.74	5.59	5.59	0.924	0.948	0.907	0.918
56	3.37	3.30	3.41	3.41	0.883	0.907	0.890	0.882
57	4.80	5.04	4.96	4.96	0.901	0.917	0.889	0.891
58	3.20	3.09	3.22	3.22	0.864	0.908	0.885	0.883

In response to the April 2015 NOPR, AHRI commented that for gas-fired instantaneous water heaters tested by DOE, most condensing units had measured UEFs that were greater than the EF, but the calculated UEF using the mathematical conversion for these units in all cases was less than the tested UEF. (AHRI, No. 13 at p. 6) NEEA commented that the UEF rating comparison results are so scattered as to strongly suggest that there are factors, which differ from one water heater to another, missing from the current analytical approach, or that one or more of DOE's assumptions or approximations used in the analytical approach are not valid for every water heater. NEEA suggested that a likely source of error may be in the methods used to estimate the amount of energy absorbed by the water heater in any given firing cycle, or the related estimates of the impact of the time between firing cycles on this factor. NEEA also commented that the conversion for gas-fired instantaneous water heaters consistently underrates the UEF of condensing water heaters and seems unable to predict reliably the measured UEF of any non-condensing models. (NEEA, No. 15 at p. 6)

In response, DOE notes that the relationship between measured UEF and EF is not a result of the conversion, but rather how water heaters are performing when tested to the UEF test procedure. In the set of data used for this rulemaking, DOE observes that 19 of the 23 condensing units have a measured UEF less than the measured EF. AHRI and NEEA commented that the conversion for condensing gas-fired instantaneous water heaters underrates the UEF. DOE notes that with the new test data and conversion factors, 7 of the condensing units have converted UEFs greater than the measured, 9 are less than, and 7 are equal to, after rounding to the second decimal place, suggesting that the proposed conversion factor contained in this SNOPR is overall, a more accurate fit to the test data than the conversion factor proposed in the NOPR. Further, the RMSD values for the NOPR and SNOPR conversions for the current set of condensing units are 0.063 and 0.017, respectively. These results indicate that the SNOPR conversion factors are better predictors of actual performance. Regarding NEEA's statement that the conversion is unable to predict reliably the measured UEF of non-condensing models, DOE notes that the RMSD value is 0.034 when applied for just non-condensing units, as compared to the RMSD value of 0.017 when applied to just condensing units, which indicates that the conversion equation for gas-fired instantaneous water heaters does fit the non-condensing data points almost as well as it fits the condensing data points. However, DOE notes that the new conversion equation for non-condensing gas-fired instantaneous water heaters produced converted UEF values above the measured UEF values for 11 units, below the measured UEF values for 11 units, and equal to for 8 units, when rounded to the second decimal place, suggesting the conversion is representing the non-condensing category as well as can be expected, given the variance in the non-condensing test data, and is not skewed toward over- or under-predicting the UEF of these units. Further, when separate conversion equations are derived for condensing and non-condensing gas-fired instantaneous water heaters, the RMSD values for non-condensing and condensing instantaneous water heaters only improve by 0.003 and 0.001, respectively. DOE has tentatively determined that this improvement is negligible when weighed against the added complexity of an additional conversion factor. As stated in section III.E.1, DOE tentatively considers a change in RMSD to be negligible if it is less than one unit (0.01 for EF and UEF, 0.1 for maximum GPM, and 1.0 for first-hour rating). In this case, 0.003 and 0.001 are less than 0.01 and would be unlikely to have a noticeable effect when UEF is rounded to the nearest 0.01 per the reporting requirements in 10 CFR 429.17. NEEA's suggestions about improving the instantaneous analytical conversion were previously discussed in section III.C.4.c of this notice.

c. Residential-Duty Commercial Storage Water Heaters

i. Test Results

DOE has tested 8 residential-duty commercial storage water heaters to both the thermal efficiency and standby loss and UEF test procedures, and AHRI has supplied test data for 12 additional units of this kind of water heater.[15] Table III.35 below presents the test data used to derive the residential-duty commercial storage water heater conversion factors. Table III.36 shows the water heater attributes by unit described in section III.E.1.

TABLE III.35—RESIDENTIAL-DUTY COMMERCIAL WATER HEATER TEST DATA

RDS No	AHRI No	Type	Storage volume (gal)	Input rate (Btu/h)	Thermal efficiency (%)	Standby loss (Btu/h)	Updated FHR (gal)	UEF
1	N/A	Gas	72.9	75,600	74.1	1007.0	107.4	0.612
2	N/A	Gas	48.3	76,500	93.6	328.0	137.0	0.816
3	N/A	Gas	93.7	78,900	80.4	1178.2	109.8	0.514
4	N/A	Gas	70.9	76,900	82.8	580.2	156.4	0.710
5	N/A	Gas	94.9	83,700	80.0	1389.9	159.2	0.524
6	N/A	Gas	69.6	75,600	76.9	1407.2	130.0	0.505
7	N/A	Oil	50.3	140,000	76.7	908.2	134.8	0.617
8	N/A	Gas	48.4	75,500	89.5	348.3	114.9	0.722
9	1–105	Gas	93.1	75,200	80.1	1163.3	140.9	0.561
10	2–14	Gas	49.0	76,800	97.3	150.0	151.1	0.908
11	2–15	Gas	49.0	76,800	97.3	150.0	156.8	0.891
12	1–122	Gas	71.3	79,600	82.7	789.0	131.0	0.650
13	1–120	Gas	49.0	76,800	97.3	150.0	154.0	0.907
14	1–114, 115.	Gas	48.3	75,100	92.6	290.5	119.1	0.877
15	1–106, 107.	Gas	70.8	74,600	80.0	1052.0	113.8	0.625
16	1–110, 111.	Gas	71.1	75,100	81.0	921.0	107.6	0.642
17	1–108, 109.	Gas	95.0	74,000	80.5	1064.5	140.0	0.596
18	1–112, 113.	Gas	94.9	74,700	81.5	1063.0	125.9	0.587
19	1–116, 117.	Gas	49.4	101,300	96.5	422.5	109.9	0.865
20	1–118, 119.	Gas	74.2	101,400	96.0	408.5	174.0	0.842

TABLE III.36—RESIDENTIAL-DUTY COMMERCIAL WATER HEATER ATTRIBUTES

RDS No	NO_X Emission level	Condensing	Vent type	Short or Tall	Standing Pilot?
1	Low	No	Power	Tall	Yes.
2	Low	Yes.	Power	Short	No
3	Standard	No	Atmospheric	Tall	Yes.
4	Standard	No	Power	Tall	No
5	Ultra-Low	No	Atmospheric	Not Specified	Yes.
6	Ultra-Low	No	Atmospheric	Tall	Yes.
7	N/A.	N/A.	N/A.	Short	N/A.
8	Low	Yes.	Power	Tall	No
9	Low	No	Atmospheric	Tall	Yes.
10	Low	Yes.	Power	Not Specified	No
11	Low	Yes.	Power	Not Specified	No
12	Low	Yes.	Power	Tall	No
13	Not Specified	Yes.	Power	Not Specified	No

[15] If multiple tests were conducted on either the same unit or same basic model of a water heater, the results were averaged to produce the values reported in this SNOPR.

TABLE III.36—RESIDENTIAL-DUTY COMMERCIAL WATER HEATER ATTRIBUTES—Continued

RDS No	NO_X Emission level	Condensing	Vent type	Short or Tall	Standing Pilot?
14	Low	Yes.	Power	Tall	No
15	Standard	No	Atmospheric	Tall	Yes.
16	Standard	No	Atmospheric	Tall	Yes.
17	Ultra-Low	No	Atmospheric	Tall	Yes.
18	Ultra-Low	No	Atmospheric	Tall	Yes.
19	Ultra-Low	Yes.	Power	Tall	No
20	Ultra-Low	Yes.	Power	Tall	No

ii. Conversion Factor Results

As stated in section III.C.4.b, DOE is not aware of an analytical model to convert the represented values of thermal efficiency and standby loss under the prior commercial test procedure to estimate the represented value of first-hour rating under the new test procedure. Therefore, DOE proposes to use the step regression method described in section III.C.2 along with the best combination of water heater attributes to determine the first-hour rating conversion factor shown in Table III.37. 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, the value can be applied to determine the appropriate draw pattern bin (*i.e.,* very small, low, medium, or high) using Table 1 of the uniform efficiency descriptor test procedure. 10 CFR 430, subpart B, appendix E, section 5.4.1. With the draw bin known, the UEF value based on the analytical model can be calculated using the process described in section III.C.4 of this document. The analytical results, along with the results of the step regression and the analytical regression, are presented in Table III.38 and have RMSD values of 0.032, 0.029, and 0.032, respectively. DOE proposes to use the combined analytical-regression approach to calculate the residential-duty commercial storage water heater conversion factor because the RMSD value is within 0.003 of that of the regression and the use of the analytical portion of the conversion will likely apply better to units that have not been tested. The resulting equations for determining the UEF of residential-duty commercial storage water heaters are presented in Table III.37. In the equations in Table III.37, V_r is the rated volume, and E_t is the thermal efficiency in fractional form (*e.g.,* 0.85 instead of 85 (%)). UEF_{rd} is the result of the analytical conversion, described in section III.C.4.c. For these regressions, DOE decided to group both oil-fired and gas-fired water heaters because of the lack of oil-fired water heaters identified.

TABLE III.37—PROPOSED RESIDENTIAL-DUTY COMMERCIAL STORAGE CONVERSION FACTOR EQUATIONS

Product class	Conversion factor
All Residential-Duty Commercial Storage Water Heaters.	New FHR = $-35.8233 + 0.4649 \times V_r + 160.5089 \times E_t$ New UEF = $-0.0022 + 1.0002 \times UEF_{rd}$

TABLE III.38—RESIDENTIAL-DUTY COMMERCIAL STORAGE CONVERSION RESULTS

RDS No.	Tested FHR (gal)	Regression FHR (gal)	Tested UEF	Analytical UEF	Regression UEF	Analytical-Regression UEF
1	107.4	117.0	0.612	0.567	0.559	0.565
2	137.0	136.9	0.816	0.830	0.831	0.828
3	109.8	136.8	0.514	0.578	0.567	0.576
4	156.4	130.1	0.710	0.691	0.700	0.689
5	159.2	136.7	0.524	0.548	0.527	0.546
6	130.0	120.0	0.505	0.532	0.509	0.530
7	134.8	110.7	0.617	0.594	0.626	0.592
8	114.9	130.3	0.722	0.793	0.798	0.790
9	140.9	136.0	0.561	0.579	0.566	0.577
10	151.1	143.2	0.908	0.918	0.890	0.916
11	156.8	143.2	0.891	0.918	0.890	0.916
12	131.0	130.1	0.650	0.651	0.662	0.649
13	154.0	143.2	0.907	0.918	0.890	0.916
14	119.1	135.2	0.877	0.833	0.830	0.831
15	113.8	125.5	0.625	0.594	0.594	0.592
16	107.6	127.3	0.642	0.620	0.625	0.617
17	140.0	137.5	0.596	0.595	0.585	0.593
18	125.9	139.1	0.587	0.601	0.593	0.599
19	109.9	142.0	0.865	0.825	0.843	0.823
20	174.0	152.8	0.842	0.825	0.832	0.823

In response to the NOPR, AHRI stated that for gas-fired residential-duty commercial storage water heaters, all the measured UEF results are higher than the converted UEF values using the mathematical conversion, and the commenters added that the magnitude of the difference seems to track with the volume and thermal efficiency of the water heater. (AHRI, No. 6 at p. 2) Bradford White stated that its results show that both the UEF and FHR are largely underestimated for residential-duty commercial gas-fired water heaters when using the conversion factors.

(Bradford White, No. 14 at p. 2) NEEA stated that for residential-duty commercial water heaters, there is so little correlation between the FHR and UEF calculated from the mathematical conversions and the measured values from testing that it is not possible at this point to use an analytical approach for determining either of these values. (NEEA, No. 15 at p. 6) NEEA elaborated that it is also not clear at this point that more testing (more sample models) would be helpful, as NEEA believes there are some missing variables/factors that are not being taken into account in the analytical methodologies. NEEA tentatively concluded that these water heaters will have to be tested in the near term in order to produce represented values of FHR and UEF that will match the represented values later when all water heaters must be re-certified based on tested values. (NEEA, No. 15 at p. 6)

In response to AHRI and Bradford White's comment about the gas-fired storage conversion underrating the UEF, DOE notes that under the conversion factor proposed in this SNOPR, there are a similar number of gas-fired residential-duty commercial units where the converted UEF is either higher or lower than the measured UEF,[16] which suggests that the new conversion is a better representation of the test data than was proposed in the NOPR. Further, the RMSD values for the NOPR and SNOPR conversions with the current data set are 0.068 and 0.032, respectively. In response to NEEA comments, DOE notes that the analytical method was updated based on other commenters' suggestions, and that the resulting new conversion tracks better with the measured data than the conversion factor equation proposed in the NOPR.

d. Residential-Duty Commercial Instantaneous Water Heaters

As discussed in section III.B, DOE did not propose a mathematical conversion for residential-duty commercial gas-fired instantaneous water heaters in the April 2015 NOPR. The definition of residential-duty commercial water heater applies to commercial equipment and specifically excludes gas-fired instantaneous water heaters with an input rating above 200,000 Btu/h. 10 CFR 431.102. As defined in EPCA, gas-fired instantaneous water heaters with an input rating at or below 200,000 Btu/h are consumer products, not commercial equipment. (42 U.S.C. 6291(27)(B)) As such, the definition of residential-duty commercial water heater definition precludes all gas-fired instantaneous water heaters from being so defined.

DOE has tentatively concluded a mathematical conversion factor and standard denominated in UEF are necessary for residential-duty commercial electric instantaneous water heaters. DOE tested 1 residential-duty commercial electric instantaneous water heater to the test procedure that was proposed in the UEF test procedure NOPR. 78 FR 66202 (Nov. 4, 2013). The maximum GPM conversion is based on a regression, and DOE included this data point for the residential-duty commercial electric instantaneous unit in that conversion without the need for further testing, because there were no substantial changes to the maximum GPM test for electric instantaneous water heaters between the UEF test procedure NOPR and final rule. Because of the small amount of data available and the relative similarity between units above and below the 12 kW cut-off between consumer and residential-duty commercial water heaters, DOE also used the 5 consumer electric instantaneous water heaters that were tested (see section III.E.2.b) in the development of the mathematical conversion factor for the maximum GPM of residential-duty commercial electric instantaneous water heaters. Table III.39 below presents the residential-duty commercial electric instantaneous water heater test data used to develop the conversion factors.

TABLE III.39—RESIDENTIAL-DUTY COMMERCIAL INSTANTANEOUS WATER HEATER TEST DATA

RDI No.	Input rate (Btu/h)	Updated max GPM	UEF
1	83,600	2.48	0.948

DOE examined potential parameters for predicting the maximum GPM rating of residential-duty commercial electric instantaneous water heaters. Given the *de minimis* losses from electric heating elements, and the *de minimis* standby losses associated with tankless water heaters, DOE believes that it is appropriate to assume that the delivery capacity would be heavily dependent on the input rating for electric instantaneous water heaters. DOE examined the predicted maximum GPM as a function of input rate, and developed an equation which results in an RMSD of 0.009 gpm. DOE proposes to use the following equation as the mathematical conversion factor for max GPM, where Q is input rate in kBtu/h.

$$New\ Max\ GPM = 0.0146 + 0.0295 * Q$$

DOE has tentatively determined that the UEF value shown in Table III.39, which is a result of the UEF test procedure NOPR is not appropriate for use in a regression based conversion. As described in section III.C.4.c.iv, DOE has proposed an analytical method for determining the UEF conversion, and as such, this test point was not necessary to develop the UEF conversion. DOE proposes to use the analytical method described in section III.C.4.c.iv as the conversion for residential-duty commercial electric instantaneous water heaters.

e. Grid-Enabled Storage Water Heaters

Grid-enabled water heaters have a rated storage volume above 75 gallons and use electric resistance elements to heat the stored water. At the time of its analysis for this notice, DOE was unable to find grid-enabled water heaters available on the market which meet the definition of ''grid-enabled water heater'' [17] as set forth in EEIA 2015. As a result, DOE does not have any test data for grid-enabled water heaters specifically. However, DOE does have a large set of data for electric resistance storage water heaters, which DOE believes would have similar energy consumption-related characteristics to grid-enabled water heaters, aside from the differences in stored volume. DOE has conducted testing of 18 consumer electric storage water heaters, which use electric resistance elements and were

[16] Of the 20 residential-duty commercial units tested, 9 had a UEF value predicted by the conversion equation that was lower than the measured UEF; 7 units had a predicted UEF that was higher than the measured UEF, and 4 units had a predicted UEF that was equal to the measured UEF, after rounding to the second decimal place.

[17] Grid-enabled water heater means an electric resistance water heater that—

(1) Has a rated storage tank volume of more than 75 gallons;

(2) Is manufactured on or after April 16, 2015;

(3) has: (i) An energy factor of not less than 1.061 minus the product obtained by multiplying—(a) the rated storage volume of the tank, expressed in gallons, and (b) 0.00168; or (2) an equivalent alternative standard prescribed by the Secretary and developed pursuant to 42 U.S.C. 6295(e)(5)(E);

(4) Is equipped at the point of manufacture with an activation lock and;

(5) Bears a permanent label applied by the manufacturer that—

(i) Is made of material not adversely affected by water;

(ii) Is attached by means of non-water-soluble adhesive; and

(iii) Advises purchasers and end-users of the intended and appropriate use of the product with the following notice printed in 16.5 point Arial Narrow Bold font: ''IMPORTANT INFORMATION: This water heater is intended only for use as part of an electric thermal storage or demand response program. It will not provide adequate hot water unless enrolled in such a program and activated by your utility company or another program operator. Confirm the availability of a program in your local area before purchasing or installing this product.''

(42 U.S.C. 6295(e)(6)(A)(ii))

tested to both the EF and UEF test procedures, and AHRI has supplied test data for 27 additional units of this water heater type. DOE believes that the electric resistance technology used in grid-enabled water heaters to heat water would be similar enough to the technology used in the less than or equal to 55 gallon class of consumer electric water heaters to be applicable in the derivation of the grid-enabled conversion and energy conservation standard derivation. Similarly, the insulation type and thickness in grid-enabled water heaters is expected to be the same as that currently used in electric storage water heaters with storage volumes less than or equal to 55 gallons. Therefore, DOE used the same test data to derive the grid-enabled consumer storage water heater conversion factors as was used to derive the consumer electric storage water heater conversion factor.

For the first-hour rating conversion, the only conversion method available is the regression approach. Therefore, the data set of electric resistance consumer electric storage water heaters was used to derive the following equation:

$$\text{New FHR} = 9.2827 + 0.8092 \times FHR_P$$

As with electric storage water heaters with storage volumes less than 55 gallons, DOE used the hybrid approach of using both the WHAM equation and a regression to calculate the UEF. Because no grid-enabled water heater products are available on the market, DOE applied the regression equations derived using the electric storage water heaters with storage volumes less than 55 gallons since the technology employed is very similar. DOE is proposing to use the following conversion equations to determine the UEF (shown as ''New UEF'' in the equation):

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

$$\text{New UEF} = 0.4474 + 0.4740 \text{ x } UEF_{WHAM}$$

DOE considered simply using the WHAM equation for the conversion of grid-enabled water heaters, but the inclusion of the regression step makes the corresponding energy conservation standards (discussed in III.E.3) more consistent with those developed for electric storage water heaters with storage volumes at or below 55 gallons, which DOE believes are very similar products at lower storage volumes. DOE seeks comment on its method of applying the regression for electric storage water heaters with storage volumes at or below 55 gallons in developing the conversion equation for grid-enabled water heaters. This is identified as issue 1 in section V.B, ''Issues on Which DOE Seeks Comment.''

3. Energy Conservation Standard Derivation

After developing the mathematical conversion factors to convert from the prior tested values under the EF metric to the tested values under the UEF metric, the next step is to translate the energy conservation standards to be in terms of UEF. In the April 2015 NOPR analysis, DOE investigated several possible methods to determine the appropriate energy conservation standards in terms of UEF, and sought comments on the various approaches. 80 FR 20116, 20136–38 (April 14, 2015). DOE ultimately proposed using the ''percent difference'' method, which would have updated the minimum standards by first calculating the percent difference between the prior EF rating and standard for each model on the market, and then applying that percent difference to the estimated UEF (based on the conversion factor) to determine the new minimum UEF requirement that maintains the same stringency. However, because the ''percent difference'' method was based on actual water heaters from the CCMS and AHRI directories, the method could only directly be applied to categories that had water heaters in them. Thus, DOE had to extrapolate standards from similar classes for categories where there were no models on the market, such as the consumer gas-fired storage water heaters greater than 55 gallons category. For this SNOPR, DOE has developed a new methodology that it proposes for translating the energy conservation standards to UEF, which DOE believes would improve the results of the standards translation. DOE has termed this new approach as the ''representative model'' method, which consists of the following steps for determining the minimum UEF standard:

1. Using the CCMS and AHRI directories, for minimally-compliant models, determine the unique rated storage volumes available on the market prior to July 13, 2015 (the date on which DOE's requirement that rated storage volume equal the mean of the measured storage volume was effective; see section III.E.3.a).

2. For each rated storage volume identified in step 1, find average values of conversion factor inputs (*i.e.,* input rating and recovery efficiency for consumer water heaters (except consumer heat pump water heaters), and input rating for residential-duty commercial water heaters) for minimally-compliant models in each product class. (For product classes where no minimally-compliant models exist on the market, DOE used other methods to estimate the characteristics of minimally-compliant models, as discussed in detail subsequently.)

3. Calculate the energy conservation standard (in terms of EF for consumer water heaters and TE/SL for residential-duty commercial water heaters (with input rate for determining standards found from step 2)) for each product class based on the rated storage volume, as reported in the CCMS and AHRI directories at the time of this analysis (before DOE's requirement that rated storage volume equal the mean of the measured storage volume was effective).

4. Using applicable average values for conversion factor inputs determined in step 2 and the applicable minimum energy conservation standards calculated in step 3, calculate the equivalent UEF for minimally-compliant models at each discrete rated storage volume (determined in step 1) using the appropriate conversion factor for the product class.

5. Adjust the rated storage volumes to estimate the rated storage volume that would reflect DOE's requirement at 10 CFR 429.17(a)(1)(ii)(C) that rated storage volume equal the mean of the measured storage volume of all units within the sample. DOE estimated that for electric storage water heaters, the rated storage volume would decrease by 10 percent, and for gas-fired and oil-fired water

heaters, the rated storage volume would decrease by 5 percent.

6. For each product class and draw pattern, using a simple regression, find the slope and intercept where the independent variable is the range of adjusted rated storage volumes (determined in step 5) and the dependent variable is the UEF values associated with the rated storage volumes and specific draw pattern calculated in step 4.

As discussed in section III.B, the energy conservation standards for water heaters established in EPCA (and for electric water heaters, the standards as adjusted by the 1990 test procedure final rule) apply to all consumer water heaters regardless of storage volume or input rate. Therefore, in addition to the classes of water heaters for which DOE proposed UEF-based standards in the NOPR, DOE is also proposing updated standards based on the UEF test procedure for the types of water heaters described in Table III.1.[18] Although there were few or no water heaters in those categories described in Table III.I, DOE used the ''representative model'' method described previously by estimating values for input rate and recovery efficiency to determine the converted UEF standard level.

For consumer gas-fired storage water heaters, there are three separate conversion factors: (1) For standard (*i.e.,* not low NO_X or ultra-low NO_X) and low NO_X non-condensing models; (2) for ultra-low NO_X non-condensing models; and (3) for condensing models. For water heaters with a storage volume less than or equal to 55 gallons, the conversion factor for standard and low NO_X non-condensing models was used to develop the proposed updated energy conservation standard, as the standard for gas-fired storage water heaters with a storage volume less than or equal to 55 gallons is at a non-condensing level. DOE chose to use the equation for standard and low NO_X non-condensing models, rather than for ultra-low NO_X non-condensing models, since standard and low NO_X non-condensing models make up the majority of the gas-fired storage water heater market. DOE considered proposing to establish separate standards for ultra-low NO_X models based on the conversion factor for these products, but found that the slight differences in the resultant standards for ultra-low-NO_X water heaters would not justify the additional complexity in the Department's water heater regulations if separate standards were to be developed. The average difference between the standard and low-NO_X and ultra-low-NO_X energy conservation standards for the very small, low, medium, and high draw patterns, was −0.041, −0.008, −0.006, and 0.003, respectively.[19] Manufacturers are required to certify UEF values rounded to the nearest 0.01 (10 CFR 429.17(b)(2)), so differences lower than that would effectively result in the same standard level for the majority of units on the market. The very small draw pattern standard would not be expected to have a negligible difference; however, DOE is not aware of any units that are on the market which would test to this draw pattern. DOE did not consider using the condensing gas-fired storage conversion for units less than or equal to 55 gallons because the resulting standard would be much more stringent than the current energy conservation standards. DOE seeks comments on the use of the standard and low-NO_X conversion to calculate the energy conservation standard for consumer gas-fired storage water heaters less than or equal to 55 gallons, and its tentative decision not to propose separate standards for ultra-low NO_X gas-fired storage water heaters. This is identified as issue 2 in section V.B, ''Issues on Which DOE Seeks Comment.''

For consumer gas-fired storage water heaters above 55 gallons, there are no water heaters on the market; therefore, DOE assumed the input rate to be 65 kBtu/h and the recovery efficiency to be 0.90 when performing the conversion to UEF for translating the standard. The input rate of 65 kBtu/h was determined based on listings available in the AHRI Directory at the time of this analysis. DOE examined all models listed in the AHRI Directory (including those marked as discontinued or obsolete) and determined that the median input rate of gas-fired storage water heaters above 55 gallons is 65 kBtu/h, which is also the most frequently occurring input rate. DOE used 0.90 as the recovery efficiency based on the recovery efficiency of the only two condensing consumer water heater models that DOE has identified on the market (both of which have storage volume below 55 gallons). DOE used these values along with the conversion factor for condensing gas-fired storage water heaters to derive the above 55-gallon energy conservation standard. DOE seeks comments from stakeholders regarding its assumptions for the typical input rating and recovery efficiency of consumer gas-fired storage water heaters above 55 gallons. This is identified as issue 3 in section V.B, ''Issues on Which DOE Seeks Comment.''

In the consumer electric instantaneous water heaters product class, there are no minimally-compliant models available on the market. Therefore, DOE estimated the recovery efficiency for minimally compliant models in order to perform the calculations required to convert the standard. The recovery efficiency of models available on the market is 0.98, while the average EF available on the market was 0.99. Given the similarity of the EF rating and recovery efficiency observed in electric instantaneous models, DOE estimated the recovery efficiency of minimally-compliant models as being equal to the EF (which at the minimally-compliant level is 0.93). DOE recognizes, however, that it is unlikely that a model using electric resistance elements would have a recovery efficiency of 0.93, but rather, it is more likely that the recovery efficiency of a minimally compliant model would be maintained at 0.98 while additional standby losses or cycling losses would result in a lower EF. Given the design of products currently on the market (upon which the conversion factor is based), both cycling and standby losses are minimal, and as a result, the conversion factor is based almost entirely on recovery efficiency. Therefore, DOE approximated a reduction in cycling and standby losses by lowering recovery efficiency such that the overall converted UEF would be lowered, in order to keep the converted standard at an equivalent level; without this reduction, the resulting standard level would be set much closer to the level of performance of current models, which would represent an increase in stringency. DOE seeks comment on this approach for estimating the recovery efficiency of a minimally-compliant (*i.e.,* 0.93 EF) electric instantaneous water heater. This is identified as issue 4 in section V.B, ''Issues on Which DOE Seeks Comment.'' The current DOE-prescribed energy conservation standard for electric instantaneous water heaters at 10 CFR 430.32(d) is at the same level

[18] These water heaters include gas-fired storage, electric storage, and tabletop water heaters at or above 2 gallons storage volume and below 20 gallons storage volume; gas-fired storage water heaters above 100 gallons storage volume; oil-fired storage water heaters above 50 gallons storage volume; electric storage water heaters above 120 gallons storage volume; gas-fired instantaneous water heaters with an input at or below 50,000 Btu/h or at or above 2 gallons storage volume; electric instantaneous water heaters at or above 2 gallons storage volume; and oil-fired electric instantaneous water heaters.

[19] Averages differences are calculated using storage volumes from 20 to 55 gallons, in increments of 1 gallon, where the minimum UEF values have been rounded to the nearest 0.01.

as those set forth in EPCA (42 U.S.C. 6295(e)(1)(C)) and shown in Table I.1. These standards are not limited by storage volume, and, therefore, DOE has tentatively decided to propose one set of standard equations for all storage volumes of consumer electric instantaneous water heaters (0 to 10.24 gallons).[20] To derive the updated energy conservation standards for consumer electric instantaneous water heaters below 2 gallons, the instantaneous conversion was used, and for units at or above 2 gallons, the storage conversion was used. DOE believes the use of the storage conversion factor for representative units at or above 2 gallons is more appropriate given the greater standby losses which would occur during the tests of these units. DOE notes that the instantaneous conversion estimates cycling losses for instantaneous water heaters and that the storage conversion estimates standby losses. Average input rates for units on the market were used for below 2 gallons units, and an input rate of 12 kW was assumed for all at or above 2 gallons units.

For grid-enabled storage water heaters, there were no minimally-compliant models available on the market at the time of analysis, so DOE assumed representative volumes of 75 and 120 gallons and input rates of 4.5 kW at both volumes.

For consumer electric storage water heaters below 20 gallons, DOE found that there were units on the market, but these units were not reported in the AHRI or CCMS databases. DOE searched through manufacturers' product literature to compile a list of units with their respective storage volumes and input rates. At each rated storage volume, the associated input rates were averaged to obtain a representative value. For consumer electric storage water heaters above 120 gallons, DOE found that there were no units on the market. Therefore, DOE assumed representative rated storage volumes of 121 gallons and 705 gallons. The upper bound of 705 gallons is the point at which the applicable EPCA standard, found in Table I.1, would be zero. The recovery efficiency is assumed to be 98 percent for all water heaters using submerged electric resistance heating elements, and the input rate for units with a capacity above 120 gallons is assumed to be 12 kW (*i.e.,* the maximum allowable input capacity in the consumer electric water heater class).

For consumer tabletop water heaters with storage volumes below 20 gallons or above 120 gallons, the current DOE-prescribed energy conservation standards are at the same level as those prescribed in the EPCA standards, found in Table I.1. Therefore, DOE tentatively proposes to extend the updated energy conservation standards derived for units between 20 and 120 gallons to all tabletop units, regardless of storage volume.

For consumer gas-fired storage water heaters, less than 20 gallons and greater than 100 gallons, DOE found that there were no units currently on the market. Therefore, DOE assumed that if such models were to exist in the less than 20 gallon size, they would have a similar representative storage volume as for consumer electric storage water heaters less than 20 gallons, and used those values as representative storage volumes. For storage volumes above 100 gallons, DOE used representative storage volumes of 101 and 326 gallons which represent the lower and upper bounds, respectively. The upper bound of 326 gallons is the point at which the applicable EPCA standard, found in Table I.1, would be zero, and DOE used this as the upper bound for storage capacity. The recovery efficiency for all units is assumed to be the average of the recovery efficiencies available for minimally compliant units between 20 and 55 gallons, which was found to be 79 percent. DOE observed in the AHRI and CCMS databases that there was one consumer gas-fired storage water heater at 20 gallons, which had an input rate of 75,000 Btu/h. This suggests that the design of consumer gas-fired storage water heaters below 20 gallons would trend towards higher input rates. Therefore, DOE assumed input rates for units below 20 gallons to be at the 4,000 Btu/h/gal limitation between storage and instantaneous water heaters, which is the maximum input allowable to be within the gas-fired storage water heater product class for a given volume. (42 U.S.C. 6291(27)(B)) An input rate of 75,000 Btu/h was used for storage volumes where the input rate using the 4,000 Btu/h/gal limitation would result in a value greater than 75,000 Btu/h, as that is the maximum input capacity for consumer gas-fired storage water heaters. For consumer gas-fired storage water heaters with greater than 100 gallons storage volume, the input rate was assumed to be 75,000 Btu/h.

For consumer oil-fired storage water heaters with a capacity above 50 gallons, recovery efficiency and input rate values are assumed to be 85 percent and 105,000 Btu/h, respectively.

For consumer oil-fired instantaneous water heaters, the maximum possible input rate as defined by EPCA at 42 U.S.C. 6291(27)(B) is 210,000 Btu/h. This input rate corresponds to a maximum storage volume of 52.5 gallons (based on the 4,000 Btu/h per gallon of stored water limitation between instantaneous and storage water heaters). Due to the large storage volumes that are possible in this class of water heater, the consumer oil-fired storage conversion was used to derive the updated UEF standards. The average storage volume, input rate, and recovery efficiency for units on the market is 5 gallons, 148,000 Btu/h, and 88 percent, respectively. Therefore, DOE used the representative market average data point along with the largest possible storage volume and input rate to determine the energy conservation standards equation in terms of UEF. A recovery efficiency of 88 percent was also used for the 52.5 gallon data point.

For consumer gas-fired instantaneous water heaters the current DOE-prescribed energy conservation standards (as amended in the April 2010 final rule and with which compliance was required in April 2015) cover models with: (1) Storage volumes below 2 gallons or (2) an input rate above 50,000 Btu/h. All other consumer gas-fired instantaneous water heaters would be subject to the standards initially established by EPCA shown in Table I.1. These two attributes are not mutually exclusive; that is, a unit could exist that has a rated storage volume at or above 2 gallons and an input rate at or below 50,000 Btu/h. DOE considered proposing a separate set of standards for each unique storage volume and input rate combination (*e.g.,* above 50,000 Btu/h and at or above 2 gallons, at or below 50,000 Btu/h and below 2 gallons, or at or below 50,000 Btu/h and at or above 2 gallons), or proposing a single standard that would cover all consumer gas-fired instantaneous water heaters with storage volume at or above 2 gallons, or input rate at or below 50,000 Btu/h. Over the range of applicable storage volumes, the methods produce UEF values that are within 0.01 of each other. Therefore, to reduce the complexity of its standards for water heaters, DOE proposes to use a single set of standard equations for consumer gas-fired instantaneous water heaters with rated storage volumes at or above 2 gallons or input rates at or below 50,000 Btu/h. Representative storage volumes of 0, 2, 12.5, and 50 gallons were used to derive the updated standards. These

[20] 10.24 gallons is the maximum possible storage volume for an electric instantaneous water heater because EPCA defines these products as having no more than one gallon of water per 4,000 Btu per hour of input and a maximum input rating of 12 kW. 12 kW converts to 40,946 Btu/h, which when divided by 4,000 Btu/h results in a maximum storage volume of 10.24 gallons to be considered as an electric instantaneous water heater.

storage volumes represent various key points. The storage volumes 0 gallons and 12.5 gallons represent the bounds of instantaneous water heaters with an input rate at or below 50,000 Btu/h. (Because an instantaneous water heater is defined as containing no more than 1 gallon of stored water per 4,000 Btu/h of input, the maximum storage volume for a 50,000 Btu/h instantaneous water heater is 12.5 gallons.) The storage volumes 2 and 50 gallons represent the bounds of instantaneous water heaters with storage volumes at or above 2 gallons. (Consumer instantaneous water heaters have a maximum input rate of 200,000 Btu/h. Because instantaneous water heaters are defined as having no more than 1 gallon of stored water per 4,000 Btu/h of input, the maximum storage volume for a 200,000 Btu/h consumer instantaneous water heater is 50 gallons.) DOE assumed that for models at or below 50,000, Btu/h the representative input rate would be 50,000 Btu/h. For the models with a storage volume at 2 gallons, DOE used the input rate at the average of models currently available on the market for minimally compliant units with 0 gallons of storage volume as the representative input rate. DOE assumed that the input rate of such a unit would be similar to models on the market with no storage volume. For models with a storage volume larger than 2 gallons, DOE assumed a representative input rate of 200,000 Btu/h. Recovery efficiencies were assumed to be 76 percent for all volumes. This recovery efficiency value is less than the average currently available on the market, but DOE believes it is more representative of a unit that would have been on the market when the EPCA standards were first prescribed. DOE used the consumer gas-fired storage conversion to derive the updated standards due to the storage volumes being in the range typically observed for storage water heaters.

For residential-duty commercial oil-fired storage water heaters, the standard increased from 78 to 80 percent in October 2015. 10 CFR 431.110. DOE used the average input rates for all residential-duty commercial oil-fired storage water heaters that comply with the amended standard to derive the inputs needed for the updated energy conservation standard.

For residential-duty commercial electric instantaneous water heaters, there were no minimally-compliant units (*i.e.,* thermal efficiency of 80 percent) on the market. As with consumer electric instantaneous water heaters, DOE recognizes that it is unlikely that a model using electric resistance elements would have a thermal efficiency of 80 percent, and the thermal efficiency of such equipment is likely to be much higher. However, DOE used the thermal efficiency value of 80 percent in calculating the equivalent UEF standard, because this represents a hypothetical minimally-compliant model. DOE used the proposed conversion equation for each draw pattern (see section III.E.2.d) to predict the UEF of a minimally-compliant model.

In response to the translated standards presented in the April 2015 NOPR, AHRI, Bradford White, and Rheem raised concerns that the stringency of the updated standards was not maintained. (AHRI, No. 13 at p. 4; Bradford White, No. 14 at p. 2; Rheem, No. 11 at p. 2) In particular, Rheem commented that 20 of the 43 consumer storage water heaters that DOE tested in support of the NOPR generated tested UEF values less than the applicable converted UEF value chosen by the DOE in the NOPR. Rheem elaborated that, in order for the stringency of energy efficiency standards to not be altered during the transition from the UEF conversion factor period to the UEF tested value period thereafter, a tested value of UEF for a water heater model should comply if its converted UEF value complies with the proposed minimum standard. (Rheem, No. 11 at p. 5) Rheem also stated that three of the seven residential-duty commercial water heaters tested by DOE have tested UEF values below their respective analytical-regression UEF values. Given that these water heaters currently comply with thermal efficiency and standby loss standards in effect and the DOE's tentative determination in the NOPR to use the analytical-regression method to generate the UEF conversion factor for residential-duty commercial water heaters, Rheem asserted that there is cause for concern that the UEF conversion factor will result in the minimum energy conservation standard for this water heater classification becoming more stringent. (Rheem, No. 11 at p. 5)

Bradford White asserted that the proposed converted standard in terms of UEF for electric storage water heaters is more stringent than the EF standard. (Bradford White, No. 14 at p. 2) AHRI also claimed that the proposed UEF standard for electric storage water heaters is too stringent, arguing that the converted UEF values for these models in the NOPR were higher than the tested UEF values and that models complying with the EF standards would not meet the UEF standards. (AHRI, No. 6 at p. 2) Rheem asserted that for consumer electric storage water heaters tested using the low draw pattern, test data consistently revealed tested UEF values three to four points below the proposed UEF minimum. For consumer electric storage water heaters tested using the medium draw pattern, Rheem observed that there were some measured UEF values two to three points below the proposed UEF minimum. (Rheem, No. 11 at p. 4) EEI stated that the proposed UEF minimums for electric storage water heaters are not neutral for products representing a large share of the consumer market. (EEI, No. 17 at p. 2)

Bradford White stated that the proposed converted standard in terms of UEF for gas-fired storage water heaters tested using the high draw pattern is less stringent than the EF standard, and that the standard for models tested using the medium draw pattern would be more or less stringent, depending on the model. (Bradford White, No. 14 at p. 2) Rheem stated that for gas-fired storage models tested using the high draw pattern, its test data showed measured UEF values two to three points higher than the proposed converted UEF standards. EEI commented that there were issues with gas-fired storage water heaters at high draw patterns, where the converted minimum UEF standard is less stringent than the EF standard. (EEI, No. 17 at p. 2)

Rheem commented that for several models tested by DOE (identified in the April 2015 NOPR as CS–6, CS–13, CS–29, CS–30, and CS–39) the measured UEF was less than the converted UEF standard. Rheem stated that for gas-fired instantaneous water heaters that would be tested with the medium draw pattern, the measured UEF is 1 point lower than the proposed minimum UEF level. Rheem also stated that for gas-fired instantaneous water heaters that would be tested with the high draw pattern, the measured UEF is consistently 2 to 3 points higher than the proposed minimum UEF level. (Rheem, No. 11 at p. 4) Further, Rheem stated that after the 1 year application period of the conversion factor, units which previously passed the minimum EF standards could test to fail the updated minimum UEF standards. (Rheem, No. 11 at p. 3)

In response to these comments, DOE acknowledges that the test data presented in section III.E.2 show that some units which previously passed the EF energy conservation standards would fail the proposed UEF standards, while other units which previously failed would now pass. As discussed in section III.A, DOE recognizes that the conversion factors presented cannot perfectly model the behavior of all water heaters, and therefore, uncertainty is carried through to deriving the updated energy conservation standards. The standards presented in Table III.40 and Table III.41 were derived using a method that was intended to reduce the number of units that would either be non-compliant under the EF test method and compliant under the UEF test method or vice versa, so as to maintain the stringency of the updated standard. Nevertheless, to ensure that water heaters which previously passed the EF energy conservation standards will continue to comply, pre-existing models that are compliant with the EF energy conservation standards are ''grandfathered,'' as described below in section III.F.

The proposed standards in terms of uniform energy factor are shown below by product class and draw pattern.

TABLE III.40—PROPOSED CONSUMER WATER HEATER ENERGY CONSERVATION STANDARDS

Product class	Rated storage volume and input rating (if applicable)	Draw pattern	Uniform energy factor
Gas-fired Storage Water Heater	<20 gal	Very Small	$0.2471 - (0.0002 \times V_r)$.
		Low	$0.5132 - (0.0012 \times V_r)$
		Medium	$0.5827 - (0.0015 \times V_r)$.
		High	$0.6507 - (0.0019 \times V_r)$.
	≥20 gal and ≤55 gal	Very Small	$0.3456 - (0.0020 \times V_r)$.
		Low	$0.5982 - (0.0019 \times V_r)$.
		Medium	$0.6483 - (0.0017 \times V_r)$.
		High	$0.6920 - (0.0013 \times V_r)$.
	>55 gal and ≤100 gal	Very Small	$0.6470 - (0.0006 \times V_r)$.
		Low	$0.7689 - (0.0005 \times V_r)$.
		Medium	$0.7897 - (0.0004 \times V_r)$.
		High	$0.8072 - (0.0003 \times V_r)$.
	>100 gal	Very Small	$0.1755 - (0.0006 \times V_r)$.
		Low	$0.4671 - (0.0015 \times V_r)$.
		Medium	$0.5719 - (0.0018 \times V_r)$.
		High	$0.6916 - (0.0022 \times V_r)$.
Oil-fired Storage Water Heater	≤50 gal	Very Small	$0.1822 - (-0.0001 \times V_r)$.
		Low	$0.5313 - (0.0014 \times V_r)$.
		Medium	$0.6316 - (0.0020 \times V_r)$.
		High	$0.7334 - (0.0028 \times V_r)$.
	>50 gal	Very Small	$0.1068 - (0.0007 \times V_r)$.
		Low	$0.4190 - (0.0017 \times V_r)$.
		Medium	$0.5255 - (0.0021 \times V_r)$.
		High	$0.6438 - (0.0025 \times V_r)$.
Electric Storage Water Heaters	<20 gal	Very Small	$0.7836 - (0.0013 \times V_r)$.
		Low	$0.8939 - (0.0008 \times V_r)$.
		Medium	$0.9112 - (0.0007 \times V_r)$.
		High	$0.9255 - (0.0006 \times V_r)$.
	≥20 gal and ≤55 gal	Very Small	$0.8808 - (0.0008 \times V_r)$.
		Low	$0.9254 - (0.0003 \times V_r)$.
		Medium	$0.9307 - (0.0002 \times V_r)$.
		High	$0.9349 - (0.0001 \times V_r)$.
	>55 gal and ≤120 gal	Very Small	$1.9236 - (0.0011 \times V_r)$.
		Low	$2.0440 - (0.0011 \times V_r)$.
		Medium	$2.1171 - (0.0011 \times V_r)$.
		High	$2.2418 - (0.0011 \times V_r)$.
	>120 gal	Very Small	$0.6802 - (0.0003 \times V_r)$.
		Low	$0.8620 - (0.0006 \times V_r)$.
		Medium	$0.9042 - (0.0007 \times V_r)$.
		High	$0.9437 - (0.0007 \times V_r)$.
Tabletop Water Heater	All	Very Small	$0.6323 - (0.0058 \times V_r)$.
		Low	$0.9188 - (0.0031 \times V_r)$.
		Medium	$0.9577 - (0.0023 \times V_r)$.
		High	$0.9884 - (0.0016 \times V_r)$.
Instantaneous Gas-fired Water Heater	<2 gal and >50,000 Btu/h	Very Small	$0.7964 - (0.0000 \times V_r)$.
		Low	$0.8055 - (0.0000 \times V_r)$.
		Medium	$0.8070 - (0.0000 \times V_r)$.
		High	$0.8086 - (0.0000 \times V_r)$.
	≥2 gal or ≤50,000 Btu/h	Very Small	$0.3013 - (0.0023 \times V_r)$.
		Low	$0.5421 - (0.0024 \times V_r)$.
		Medium	$0.5942 - (0.0021 \times V_r)$.
		High	$0.6415 - (0.0017 \times V_r)$.
Instantaneous Oil-fired Water Heater	All	Very Small	$0.1430 - (0.0015 \times V_r)$.
		Low	$0.4455 - (0.0023 \times V_r)$.
		Medium	$0.5339 - (0.0023 \times V_r)$.
		High	$0.6245 - (0.0021 \times V_r)$.
Instantaneous Electric Water Heater	All	Very Small	$0.9161 - (0.0039 \times V_r)$.
		Low	$0.9159 - (0.0009 \times V_r)$.
		Medium	$0.9160 - (0.0005 \times V_r)$.
		High	$0.9161 - (0.0003 \times V_r)$.
Grid-Enabled Water Heater	>75 gal	Very Small	$1.0136 - (0.0028 \times V_r)$.

TABLE III.40—PROPOSED CONSUMER WATER HEATER ENERGY CONSERVATION STANDARDS—Continued

Product class	Rated storage volume and input rating (if applicable)	Draw pattern	Uniform energy factor
		Low	$0.9984 - (0.0014 \times V_r)$.
		Medium	$0.9853 - (0.0010 \times V_r)$.
		High	$0.9720 - (0.0007 \times V_r)$.

* 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.41—PROPOSED RESIDENTIAL-DUTY COMMERCIAL WATER HEATER ENERGY CONSERVATION STANDARDS

Product class	Draw pattern	Uniform energy factor
Gas-fired Storage	Very Small	$0.2670 - (0.0009 \times V_r)$.
	Low	$0.5356 - (0.0012 \times V_r)$.
	Medium	$0.5996 - (0.0011 \times V_r)$.
	High	$0.6592 - (0.0009 \times V_r)$.
Oil-fired Storage	Very Small	$0.2932 - (0.0015 \times V_r)$.
	Low	$0.5596 - (0.0018 \times V_r)$.
	Medium	$0.6194 - (0.0016 \times V_r)$.
	High	$0.6740 - (0.0013 \times V_r)$.
Electric Instantaneous	Very Small	0.80
	Low	0.80
	Medium	0.80
	High	0.80

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

Lutz suggested determining the energy conservation standards using only test data from minimally-compliant water heaters. He stated that this method would remove the uncertainty which compounds throughout the conversion process. (Lutz, No. 16 at p. 3) DOE believes that an appropriate amount of minimally-compliant water heater test data is currently not present to pursue this method. Based on stakeholder comments, DOE selected units for testing with a range of attributes and associated EF levels. As the effect of the uniform efficiency descriptor test procedure cannot be fully known without testing all units on the market, it is a possibility that a minimally compliant unit may perform better than a unit that was rated above the minimum. Further, a water heater would have to have a tested EF at the minimum energy conservation standard, not just be rated at the minimum. Therefore, for these reasons, DOE did not use this method for deriving the proposed standards.

Rheem and AHRI argued that the relative difference between the minimum EF and EF should be maintained between the minimum UEF and UEF values. (Rheem, No. 11 at p. 3; AHRI, No. 6 at p. 2) AHRI also asserted that if the relative difference is not maintained, then a manufacturer's investment could be wasted. (AHRI, No. 3 at p. 2) AHRI expressed the view that it is more important to look at the difference in the measurements between the EF and UEF test procedures, and recommended that DOE should examine the difference in EF and UEF measurements for models rated at the applicable minimum EF value to help check the validity of the proposed converted minimum standards. (AHRI, No. 13 at p. 5) DOE agrees that the relative difference between minimum and rated values is an important factor to consider when developing the energy conservation standards. The proposed ''representative model'' method uses the EF-denominated energy conservation standard values to derive the new standard equations; therefore, DOE believes the stringency of the standards is maintained for the market as a whole. However, test data show that water heaters do not all have the same reaction to the new test procedure, and as such, the relative difference in the standards cannot be exactly maintained for each individual model. In addition, not all manufacturers rate models with the same degree of conservativism, so the relationship between rated and measured values is not constant.

Regarding specifically the energy conservation standards for the residential-duty commercial water heater equipment class, EEI stated that this was a non-standard process for creating the proposed standards. (EEI, No. 5 at p. 2) In response, DOE clarifies that DOE is not creating new standards for residential-duty commercial water heaters. Rather, this equipment has always been covered under the applicable commercial water heating equipment standards. DOE is simply translating the commercial water heating equipment standards from the thermal efficiency and standby loss metrics in use today to the UEF metric for the subset of commercial water heating equipment that would meet the definition of a ''residential-duty commercial water heater'' at 10 CFR 431.102.

a. Storage Volume Used for Calculations

In the July 2014 final rule, DOE amended the certification requirements for consumer water heaters to specify that the rated storage volume of a water heater is the mean of the measured storage volume. 79 FR 40542, 40565 (July 11, 2014). Commenters requested clarification on how the rated storage volume will be applied in this rulemaking. (AHRI, No. 3 at p. 2; A. O. Smith, No. 13 at p. 2; Bradford White, No. 14 at p. 3; NEEA, No. 15 at p. 7; Rheem, No. 11 at p. 8)

As discussed in the preceding section, DOE has accounted for the amended certification requirements with regard to the rated storage volume in this rulemaking when translating the standards. First, DOE used the rated storage volumes prior to the effective date of the requirement that the rated storage volume of a water heater be the mean of the measured storage volume to calculate the EF-denominated standards with which to maintain equivalency for each model. Therefore, the stringency of the EF-denominated standards that DOE converted did not change due to the new certification requirements. Second, when calculating the converted UEF standards equations, DOE adjusted the rated storage volume to reflect its new requirement that the rated storage volume be equal to the mean of the measured volume of units in the certification sample (since the storage volumes initially examined were certified prior to the effective date of this requirement).

Before DOE instituted this requirement, a manufacturer had some freedom to choose a volume rating, subject to industry safety standards under which a rated volume had to be within 5 percent of the actual volume for a fossil-fuel-fired water heater or within 10 percent for an electric water heater. Meanwhile, the operation of DOE's energy conservation standard for water heaters gave manufacturers an incentive to rate the volumes of their products as high as possible—because the applicable standard decreased for larger volumes. The combined effect of these two influences, DOE believes, is that fossil-fuel-fired water heaters ordinarily had volume ratings 5 percent higher than their actual volumes, and electric water heaters 10 percent higher. DOE's observations on actual products is consistent with that conclusion.

Consequently, DOE estimated the measured volume as 0.95 times (*i.e.,* 5 percent lower than) the rated storage volume for fossil fuel fired water heaters and 0.90 times (*i.e.,* 10 percent lower than) the rated storage volume for electric water heaters. By adjusting the storage volume to reflect what will be the new rated storage volumes that are 5 percent or 10 percent (for fossil fuel and electric water heaters, respectively) below the previous rated storage volume, DOE has accounted for the change in its regulations regarding the rating of storage volumes, and the UEF standard equation will represent the relationship between the new rated storage volume (equivalent to the mean of the measured storage volume for test samples) and UEF. Figure III.1 below shows an example representation of how the energy conservation standards are related to each other based on the rated or estimated measured storage volumes.

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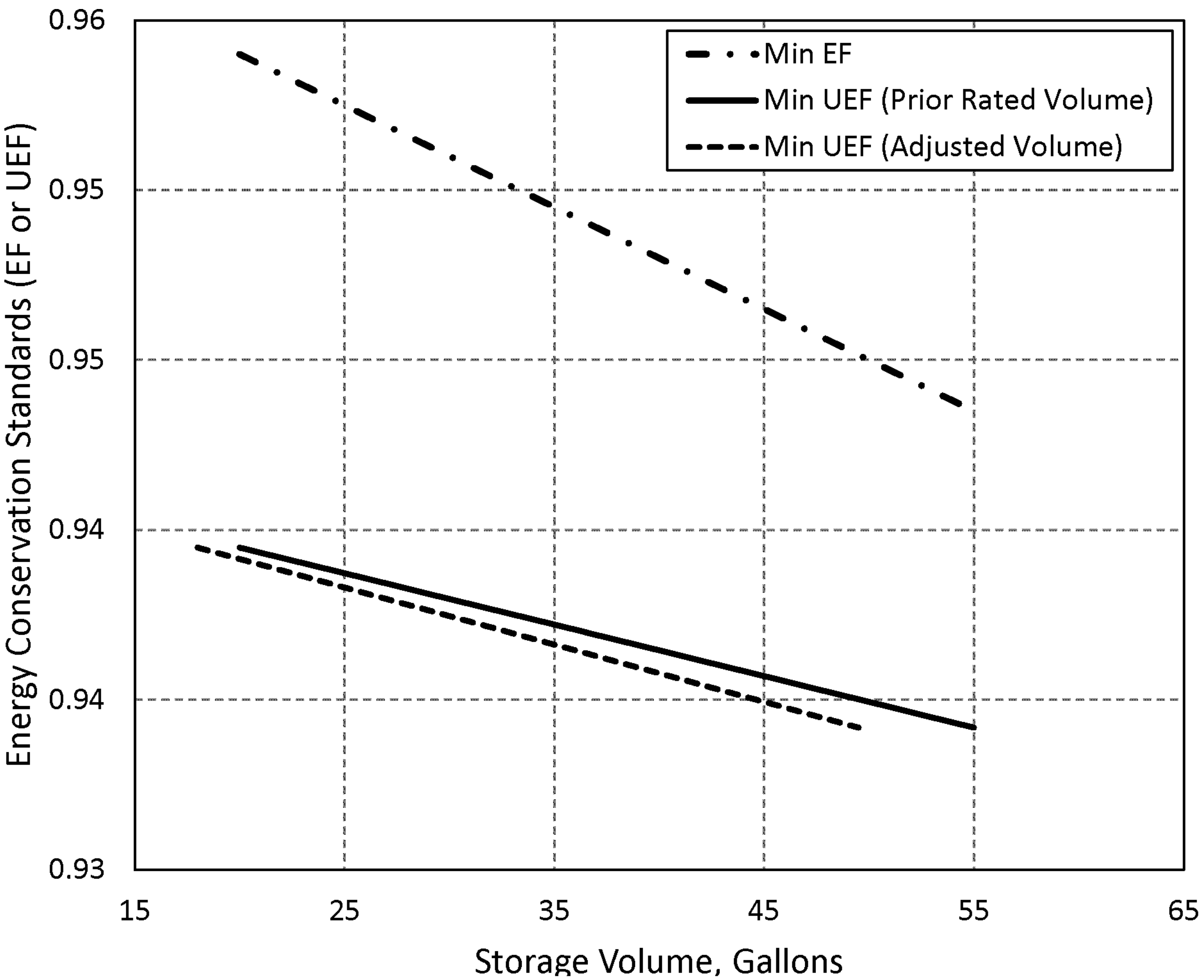

Figure III.1 – Example Representation of Relationship between Storage Volume and the Energy Conservation Standard for Electric Storage Water Heaters

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In the July 2014 test procedure final rule, DOE added enforcement provisions that state that the rated value for storage volume during enforcement testing will be considered valid only if the measurement is within 5 percent of the certified rating. If the rated storage volume is within 5 percent of the mean of the measured value of storage volume, then that value will be used as the basis for calculation of the required uniform energy factor for the basic model; otherwise, the mean of the measured values will be used as the basis for calculation of the required uniform energy factor for the basic model. 79 FR 40542, 40566 (July 11, 2014); 10 CFR 429.134(d)(2). DOE reviewed the measured storage volume test data for models included in the analysis for this SNOPR and observed that for models which were tested more than once, the measured storage volume was well within five percent of the mean of the measured storage volumes (which will be required to be equal to the rated storage volume under 10 CFR 429.17(a)(1)(ii)(C)) for each respective model. The data set of models tested more than once consists of 10 unique models with 24 total storage volume tests (each model was tested 2 or 3 times). For each model, DOE calculated the mean, standard deviation, and 99.7-percent confidence interval (*i.e.,* 3 times the standard deviation of the measured storage volumes) of the measured storage volumes. DOE then compared the mean of the measured storage volume to the 99.7-percent confidence interval to determine the percent deviation from the mean value that would be within the 99.7-percent confidence interval. The maximum percent change from the mean that would be within the 99.7-percent confidence interval was slightly under one percent. Therefore, DOE proposes to change its enforcement-specific provisions for water heaters to specify that the rated value for storage volume during enforcement testing will be considered valid only if the measurement is within 2 percent of the certified rating. DOE believes two percent more accurately reflects the level of variability that manufacturers are currently able to achieve, and allows for slightly more variability than what was observed in the sample set of this SNOPR.

F. Compliance and Grandfathering

AHRI, Bradford White, Rheem, and EEI recommended that DOE should add provisions to state that any water heater models tested and meeting the minimum EF requirements prior to July 13, 2015 (*i.e.,* those meeting the standards promulgated in the April 2010 final rule and requiring compliance on April 16, 2015), would be considered as meeting the minimum UEF requirements. (AHRI, No. 13 at p. 8; Bradford White, No. 14 at p. 2; Rheem, No. 11 at p. 3; EEI, No. 17 at p. 3) AHRI, Bradford White, and EEI stated that the proposed standards are to be neither more nor less stringent than the EF-denominated standards, as stated in 42 U.S.C. 6293(e), and that this implies grandfathering water heater models will be included in this rulemaking. (AHRI, No. 13 at p. 8; Bradford White, No. 14 at p. 1; EEI, No. 17 at p. 3) Further, Rheem argued that at the time of the switch from allowing the converted UEF to requiring the tested UEF for demonstrating compliance, a tested UEF value should comply if the converted value passes. (Rheem, No. 11 at p. 5) EEI asserted that compliance or non-compliance with the standard can only be determined through the test procedure and that a unit which meets the efficiency standard under the old test procedure should be valid for sale, regardless of the conversion factor result. (EEI, No. 17 at p. 3) EEI also argued that the conversion values should only be used on the FTC EnergyGuide label. (EEI, No. 17 at p. 3) AHRI stated that the converted minimum UEF standards will not have perfect one-to-one correlation with every currently complying model, and therefore, it is essential that DOE establish how grandfathering will be applied so that manufacturers can properly assess the validity of the converted minimum UEF standards. (AHRI, No. 13 at p. 8)

In a paragraph titled ''Existing covered water heaters,'' EPCA provides that a covered water heater (*i.e.,* a water heater subject to the UEF test procedure rule) is considered to comply with the UEF test procedure rule on and after the effective date of the final rule (*i.e.,* July 13, 2015) and with any revised labeling requirements established by the Federal Trade Commission (FTC) to carry out the final rule if the covered water heater was manufactured prior to the effective date of the final rule; and (ii) complied with the efficiency standards and labeling requirements in effect prior to the final rule. (42 U.S.C. 6295(e)(5)(K)) EPCA defines the ''final rule,'' in this context, to be the UEF test procedure final rule. (42 U.S.C. 6295(e)(5)(A)(ii)) The natural reading of this provision is that a water heater (a unit [21]) manufactured prior to July 13, 2015, and compliant with the pre-existing standards when tested using the test procedure in effect on July 13, 2014, is deemed to comply with the UEF test procedure final rule and any corresponding label changes made by the FTC.

Manufacturers appear to read this provision to provide ''grandfathering'' with respect to compliance with the converted standards. The language does not provide such relief, nor is such relief necessary. The standard applicable to a unit is the standard in effect at the time of manufacture; therefore, units manufactured prior to July 13, 2015, must comply with the corresponding EF/TE/STB standards, and no ''grandfathering'' is needed. The relevance of the UEF test procedure with respect to such units is for the purposes of representations, which this statutory provision explicitly addresses. Accordingly, DOE reads 42 U.S.C. 6295(e)(5)(K) to provide that manufacturers do not have to retest units of water heaters using the UEF test procedure if they were tested and rated prior to July 13, 2015. DOE notes there is a corresponding provision with respect to the FTC label.

In addition, EPCA provides that manufacturers may use the conversion factor in lieu of testing for models tested prior to July 13, 2015, for a period of one year following the publication of a final rule. In this way, EPCA provides additional relief to manufacturers for models of water heaters that continue to be manufactured on or after July 13, 2015, by delaying the need to complete testing using the UEF test procedure for those models of water heaters manufactured prior to July 13, 2015. *See* 42 U.S.C. 6295(e)(5)(E) (indicating the conversion factor applies to ''*models* of covered water heaters'' (emphasis added)); *compare* 42 U.S.C. 6295(e)(5)(K) (referring to ''existing covered water heaters'' and ''a covered water heater'' rather than a ''model of covered water heater'').

DOE recognizes that the nature of this conversion process could conceivably result in a few models very close to the standard falling below the converted standard. Although the statute does not provide ''grandfathering'' of the sort envisioned by manufacturers, DOE believes that there is value in reducing the uncertainty for manufacturers and that there is no significant public harm in letting manufacturers continue sales of certain models. As discussed in great detail throughout this notice, every model responds slightly differently to the change in the test procedure. As a result, there is variability, and units very near the standard level (either above or below) could have a measured efficiency using the new test procedure that would change the compliance status of that unit. Accordingly, DOE will determine the compliance of a basic model—the level of granularity typically used by DOE and manufacturers to evaluate compliance—using the test procedure in effect prior to July 13, 2015, under the following circumstance: The basic model must have been in distribution in commerce prior to July 13, 2015; the basic model must have been tested and properly certified to

[21] DOE notes that EPCA appears to distinguish in paragraph (e)(5) of section 6295 between certain provisions that apply on a unit-by-unit basis and other provisions that apply on a model-by-model basis.

DOE as compliant with the applicable standard prior to July 13, 2015; and the units manufactured prior to July 13, 2015, must be essentially identical to the units manufactured on or after July 13, 2015. The last requirement for this policy—that units must be essentially identical—bears explanation. DOE generally permits manufacturers great latitude in assigning basic model numbers, and manufacturers normally are not required to certify a model as a new basic model if modifications make the model more efficient. In implementing this policy, DOE believes that, if a manufacturer makes changes to a model (that make it either more efficient or less), then it should conduct the requisite testing using the UEF test procedure and ensure the compliance of the model with the converted standard. This policy is intended to give certainty to manufacturers with respect to historical models; it is not intended to provide a mechanism to perpetuate an obsolete test method and obsolete metrics.

In summary, EPCA provides that units of water heaters can continue to have their efficiency represented in terms of the ''old'' metrics. EPCA also provides that manufacturers can use the conversion factors to determine represented values for a period of one year following issuance of a final rule in this rulemaking for models that were being manufactured prior to July 13, 2015. Under EPCA, units manufactured on or after July 13, 2015, must meet the standard as denominated in the UEF metric; however, DOE will implement an enforcement policy that DOE will not seek civil penalties for the continued manufacture and distribution in commerce of units of certain basic models as follows: The basic model must have been in distribution in commerce prior to July 13, 2015; the basic model must have been tested and properly certified to DOE as compliant with the applicable standard prior to July 13, 2015; and the units manufactured prior to July 13, 2015, must be essentially identical to the units manufactured on or after July 13, 2015.

DOE recognizes that manufacturers seek certainty that models introduced since July 13, 2015, will not be subject to civil penalties. In enforcing the standard(s), DOE will consider whether these models meet the standard(s) as denoted using the ''old'' metric(s), the deviation from the UEF standard when tested using the UEF test procedure, and efforts taken by the manufacturer to ensure compliance with the converted, UEF standards. DOE does not intend to issue a ''grandfathering'' enforcement policy with respect to basic models introduced on and after July 13, 2015, as such a policy does not appear to be necessary at this time.

G. Certification

EPCA requires that the standard for covered water heaters be in terms of UEF as of July 13, 2015. Accordingly, in the April 2015 NOPR, DOE proposed to require manufacturers to provide EF and UEF for consumer water heaters (or thermal efficiency and standby loss and UEF for residential-duty commercial water heaters) in certification reports filed between July 13, 2015, and the compliance date determined by the final rule in this rulemaking. 80 FR 20116, 20138 (April 14, 2015). DOE proposed that manufacturers would not be required to submit revised certification reports for previously certified basic models until the next annual certification date (May 1). *Id.*

In the April 2015 NOPR, DOE noted that 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. DOE stated that 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. Lastly, DOE stated that it 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. *Id.*

In his comments, Lutz requested that standby heat loss coefficient (UA), Annual Energy Consumption (E_{annual}), Annual Electrical Energy Consumption ($E_{annual,e}$), and Annual Fossil Fuel Energy Consumption ($E_{annual,f}$) be included in the parameters manufacturers are required to submit to DOE and further that they be available to the public in the Compliance Certification Database. Lutz stated that these parameters are already calculated during the UEF test procedure and would help analysts estimate energy consumption of water heaters when operating under conditions that do not exactly match the draw patterns or other conditions specified in the laboratory test procedure. (Lutz, No. 20 at p. 1) DOE has tentatively decided not to add these values as part of the certification report; however, DOE is specifically requesting comment from stakeholders about whether these performance characteristics should be added in the final rule, either as publicly reported characteristics of water heaters or as information that is not published on the DOE Web site.

AHRI, A.O. Smith, and Rheem commented that DOE should delay the effective date of the uniform energy descriptor test procedure. (AHRI, No. 13 at p. 3; A.O. Smith, No. 10 at pp. 1–2; Rheem, No. 11 at p. 10) Specifically, AHRI argued that the statutory timeline cannot override the substantive statutory protections that Congress provided, and it is imperative that DOE take the time and effort to conduct the testing and analysis necessary to ensure that the statutory requirements are met. AHRI also stated that to proceed with implementing the UED test procedure on July 13, 2015, without the existence of appropriate conversion factors, would violate the statute and serve no purpose except to further confuse an already complex situation. (AHRI, No. 13 at pp. 2–3) A.O. Smith urged the postponement of the implementation date because new models would be tested to the new test method and have a valid UEF rating, but without a valid conversion factor in place to convert the relevant minimum efficiency requirement into terms of UEF, there is no basis for determining whether the new model is compliant with minimum efficiency standards. (A.O. Smith, No. 10 at pp. 1–2) Rheem stated that new consumer water heater models introduced in the time period between the compliance date of the amended test procedure and the conversion of the minimum standards will have to be certified with the UEF descriptor in accordance with the UEF test procedure rule, but there will be no established minimum UEF standard for that model to achieve. Rheem asserted that such uncertainty will prevent the launch of new consumer water heater models and cause significant harm to Rheem and its customers. Rheem requested a delay in implementation of the uniform energy descriptor to permit the necessary changes to product and carton labeling and communications that display energy efficiency metrics for all manufactured consumer and residential-duty commercial water heater units. (Rheem, No. 11 at pp. 9–10). NEEA strongly supported the Department's proposal to defer re-certification of existing water heater models until May 2016, noting that manufacturers would need time to transition to the UEF testing and/or calculation regime specified as a result of this rulemaking. (NEEA, No. 15 at p. 7)

Several commenters also cited the complexities of coordinating the DOE metric change with the FTC labelling process, and argued that the need for coordination with FTC should delay the implementation of the uniform efficiency descriptor. A.O. Smith stated the need to coordinate FTC labeling rules with the UEF requirements as a reason to delay implementation, and elaborated that without a valid set of conversion factors, a manufacturer will not be able to ''back calculate'' cost of operation for the FTC label from a tested UEF. (A.O. Smith, No. 10 at p. 2) GE commented that DOE should harmonize with the FTC labeling process, and fully implement the UEF and conversion once the FTC label has been modified to account for the different usage patterns in the UEF test method. (GE, No. 12 at p. 2) Rheem recommended postponing the adoption of reporting requirements until FTC has had an opportunity to evaluate the EnergyGuide label and revise its format to reflect the metrics derived from the UEF. Rheem noted that the FTC label requires information based on the measurement of EF and that a conversion method would be needed to calculate the EF based on the UEF. Rheem stated that such conversions for marketing and labeling materials will result in displays of performance and cost metrics based upon two different energy efficiency descriptors, which will confuse consumers. Rheem also raised concerns that the differences in energy and water consumption based on the delivery capacity in the UEF test method will lead to differences in annual operating costs reported on the label, which could create an incentive for manufacturers to display the information based on UEF for low and medium usage water heaters in order to display expected lower operating costs. (Rheem, No. 11 at p. 9) AHRI stated that, after the compliance date of the UEF test procedure, DOE will require manufacturers to certify UEF values, but for the FTC label, manufacturers must also have EF-based information. Although DOE had proposed not to require updated certification reports containing represented values for UEF until May 1, 2016, AHRI asserted that to comply with the information requirements of EPCA under section 6293(c), manufacturers must provide the market with UEF-based information. AHRI stated that FTC enforces both the EnergyGuide information and general manufacturer claims regarding their products under the unfair and deceptive trade practices provisions pursuant to section 6303(c), and if manufacturers display information not in conformance with Federally-mandated test procedures, this may be considered a deceptive trade practice. (AHRI, No. 13 at p. 2)

DOE understands the difficulties created by the timing of both the uniform efficiency descriptor rulemaking and the present conversion factor rulemaking for covered water heaters. However, these rulemakings dealt with matters of significant complexity and necessitated a substantial amount of testing to ensure the accuracy and validity of results, as reflected by requests from industry for extended comment periods and additional DOE testing. Consequently, DOE was not able to meet the regulatory timeline envisioned by Congress, and as a result, the Department seeks to alleviate any hardships raised by the current timeline.

Upon the effective date of the final rule that results from this rulemaking, certification of compliance with energy conservation standards will be exclusively in terms of UEF. DOE has tentatively concluded that there will be three possible paths available to manufacturers for certifying compliance of basic models of consumer water heaters that were certified before July 13, 2015: (1) In the year following the final rule in this rulemaking, convert the energy factor values 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 from energy factor to uniform energy factor using the applicable mathematical conversion factor, and then use the converted uniform energy factors along with the applicable sampling provisions in 10 CFR part 429 to determine the represented uniform energy 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 paths available to manufacturers for certifying compliance of basic models of commercial residential-duty water heaters that were certified before July 13, 2015: (1) In the year following the final rule in this rulemaking, convert the thermal efficiency and standby loss values obtained using the test procedure contained in 10 CFR 431.106 of the January 1, 2015 edition of the CFR from thermal efficiency and standby loss to uniform energy factor using the applicable mathematical conversion factor, and then use the converted uniform energy factors along with the applicable sampling provision in 10 CFR part 429 to determine the represented uniform energy 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.

DOE has already issued an enforcement policy not to seek civil penalties for certification violations during the pendency of this rulemaking. Under that policy, manufacturers are not held accountable for submitting certification reports until a conversion factor final rule is published. DOE intends to extend the certification portion of that policy for an appropriate time period to allow manufacturers to certify compliance using the conversion factors. DOE notes that certification of basic models that were certified prior to July 13, 2015, will only require the application of the appropriate conversion formula(s) from the final rule and, thus, should not require a significant amount of time to complete certification. As the test procedure has been final for more than a year, DOE also expects that the time to complete certification for basic models introduced after July 13, 2015, will not be significant. DOE welcomes data from industry regarding the necessary time to submit such reports.

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 Web site: *http://energy.gov/gc/office-general-counsel.*

This proposed rule would prescribe a mathematical conversion that would be used on a limited basis to determine the represented values 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 energy factor, thermal efficiency, and standby loss test procedures (as applicable) and the uniform energy factor test procedure. 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), at 77 FR 49991, 50008–11 (August 20, 2012), and at 81 FR 4469, 4490 (Jan. 26, 2016), 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 *https://www.sba.gov/sites/default/files/files/Size_Standards_Table.pdf.* Consumer water heater manufacturing is classified under NAICS code 335228—''Other Major Household Appliance Manufacturing.'' The SBA sets a threshold of 1,000 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 11 manufacturers of consumer water heaters that can be considered small businesses. DOE identified five manufacturers of ''residential-duty'' commercial water heaters that can be considered small businesses. Four of the ''residential-duty'' commercial water heater manufacturers also manufacture consumer water heaters, so the total number of small water heater manufacturers impacted by this rule would be 12. DOE's research involved reviewing several industry trade association membership directories (*e.g.,* AHRI), product databases (*e.g.,* CCMS, 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 energy factor test procedure and energy conservation standards, the conversion factor in this proposed rule would convert the rated values based on the energy factor test procedure to values based on the uniform energy factor test procedure. Likewise, 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 previous test procedure to the uniform descriptor which is based on the UEF test procedure. The energy conservation standards for commercial water heating equipment will be denominated using the uniform descriptor.

The conversion factor proposal accomplishes two tasks: (1) Translating the EF-, TE-, and SL-denominated (as applicable) energy conservation standards for consumer water heaters and certain commercial water heaters to being expressed in terms of the metric and test procedure for uniform energy factor; and (2) providing a limited conversion factor that manufacturers can use to translate represented values established for basic models certified prior to July 13, 2015. This limited conversion is a burden-reducing measure which helps to ease the transition of the market to the new test procedure and uniform metric over the one-year period instead of the typical 180 day timeframe allotted by statute. In addition, as discussed in section III.F, DOE will implement an enforcement policy that DOE will not seek civil penalties for the continued manufacture and distribution in commerce of units of certain basic models that meet certain conditions (as described in III.F), thereby further reducing any burden on small business manufacturers. Accordingly, DOE concludes and certifies that this rule, if finalized, 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 was approved by OMB under OMB control number 1910–1400, and this conversion-factor rule does not constitute a significant change to the requirement. 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 prior efficiency and delivery capacity metrics (and related energy conservation standard requirements) for consumer and certain commercial water heaters to the uniform efficiency 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. Public Law 104–4, sec. 201 (codified at 2 U.S.C. 1531). For a proposed regulatory action likely to result in a rule that may cause the expenditure by State, local, and Tribal governments, in the aggregate, or by the private sector of $100 million or more in any one year (adjusted annually for inflation), section 202 of UMRA requires a Federal agency to publish a written statement that estimates the resulting costs, benefits, and other effects on the national economy. (2 U.S.C. 1532(a), (b)) The UMRA also requires a Federal agency to develop an effective process to permit timely input by elected officers of State, local, and Tribal governments on a proposed ''significant intergovernmental mandate,'' and requires an agency plan for giving notice and opportunity for timely input to potentially affected small governments before establishing any requirements that might significantly or uniquely affect them. On March 18, 1997, DOE published a statement of policy on its process for intergovernmental consultation under UMRA. 62 FR 12820. (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 (Public Law 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 (Public Law 93–275), as amended by the Federal Energy Administration Authorization Act of 1977 (Public Law 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 supplemental proposed rule, no later than the date provided in the **DATES** section at the beginning of this SNOPR. Interested parties may submit comments, data, and other information using any of the methods described in the **ADDRESSES** section at the beginning of this document.

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

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

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

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. Is DOE's method of applying the regression for electric storage water heaters with storage volumes at or below 55 gallons in developing the conversion equation for grid-enabled water heaters appropriate?

2. Is DOE's use of the standard and low-NO_X conversion to calculate the energy conservation standard for consumer gas-fired storage water heaters less than or equal to 55 gallons, and its tentative decision not to propose separate standards for ultra-low-NO_X gas-fired storage water heaters appropriate?

3. Are DOE's assumptions for the typical input rating and recovery efficiency of consumer gas-fired storage water heaters above 55 gallons appropriate?

4. Is DOE's approach for estimating the recovery efficiency of a minimally-compliant (*i.e.,* 0.93 EF) electric instantaneous water heater appropriate?

VI. Approval of the Office of the Secretary

The Secretary of Energy has approved publication of this supplemental 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 August 15, 2016.

Kathleen B. Hogan,

Deputy Assistant Secretary for Energy Efficiency, Energy Efficiency and Renewable Energy.

For the reasons stated in the preamble, DOE proposes 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; 28 U.S.C. 2461 note.

■ 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 energy consumption or other measure of energy use 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 i^{th} sample;

Or,

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

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

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).

(B) Any represented value of energy efficiency 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 i^{th} sample;

Or,

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

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

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).

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

(D) 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.

(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) Determine the represented value for each basic model 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 of paragraph (a)(1); or

(ii) Calculate the uniform energy factor for each test sample by applying the following mathematical conversion factors to test data previously obtained through testing according to 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. Represented values of uniform energy factor, first-hour rating, and maximum GPM rating based on a calculation using this mathematical conversion factor must be determined using the applicable sampling provisions in paragraphs (a)(1)(i) and (a)(1)(ii) of this section.

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

Product class	Distinguishing criteria	Conversion factor *
Consumer Gas-fired Water Heater	Non-Condensing, Standard and Low NO_X	New FHR = 7.9592 + 0.8752 × FHR_P. New UEF = −0.0002 + 0.9858 × UEF_{WHAM}.
	Non-Condensing, Ultra-Low NO_X	New FHR = 25.0680 + 0.6535 × FHR_P. New UEF = 0.0746 + 0.8653 × UEF_{WHAM}.
	Condensing	New FHR = 1.0570 × FHR_P. New UEF = 0.4242 + 0.4641 × UEF_{WHAM}.
Consumer Oil-fired Water Heater	N/A	New FHR = 1.1012 × FHR_P. New UEF = −0.0934 + 1.1144 × UEF_{WHAM}.
Consumer Electric Water Heater	Electric Resistance	New FHR = 9.2827 + 0.8092 × FHR_P. New UEF = 0.4774 + 0.4740 × UEF_{WHAM}.
	Heat Pump	New FHR = −4.2705 + 0.9947 × FHR_P. New UEF = 0.1513 + 0.8407 × EF + 0.0043 × DV.
Tabletop Water Heater	N/A	New FHR = 41.5127 + 0.1989 × FHR_P. New UEF = −0.3305 + 1.3983 × UEF_{WHAM}.
Instantaneous Gas-fired Water Heater	N/A	New Max GPM = 1.1461 × Max GPM_P. New UEF = 0.1006 + 0.8622 × UEF_{model}.
Instantaneous Electric Water Heater	N/A	New Max GPM = 1.1461 × Max GPM_P. New UEF = 0.9847 × UEF_{model}.
Grid-Enabled Water Heater	N/A	New FHR = 9.2827 + 0.8092 × FHR_P. New UEF = 0.4774 + 0.4740 × UEF_{WHAM}.
Residential-Duty Commercial Gas-fired Water Heater.	N/A	New FHR = −35.8233 + 0.4649 × V_r + 160.5089 × E_t. New UEF = −0.0022 + 1.0002 × UEF_{rd}.
Residential-Duty Commercial Oil-fired Water Heater.	N/A	New FHR = −35.8233 + 0.4649 × V_r + 160.5089 × E_t. New UEF = −0.0022 + 1.0002 × UEFrd.

Product class	Distinguishing criteria	Conversion factor*
Residential-Duty Commercial Electric Instantaneous Water Heater.	N/A	New Max GPM = 0.0146 + 0.0295 × Q. New UEF = $UEF_{rd,\ model}$.

* FHR_P = prior first-hour rating.
Max GPM_P = prior max GPM rating.
Q = nameplate input rate, in kBtu/h.
E_t = thermal efficiency rating.
UEF_{WHAM} = the UEF predicted based on the WHAM equation for consumer storage water heaters, as defined in paragraph (a)(2)(ii)(B) of this section.
UEF_{rd} = the modified WHAM for residential-duty commercial water heaters, as defined in paragraph (a)(2)(ii)(B) of this section.
UEF_{model} = the UEF predicted based on the analytical model developed by DOE for consumer instantaneous water heaters, as defined in paragraph (a)(2)(ii)(B) of this section.
$UEF_{rd\ model}$ = the UEF predicted based on the analytical model developed by DOE for residential-duty commercial instantaneous water heaters, as defined in paragraph (a)(2)(ii)(B) of this section.
DV = drawn volume of water in UEF simulated-use test.
V_r = rated storage volume in gallons.

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

(*1*) For consumer storage water heaters:

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

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

Draw pattern	a	b	c	d
Very Small	0.250266	57.5	0.039864	67.5
Low	0.065860	57.5	0.039864	67.5
Medium	0.045503	57.5	0.039864	67.5
High	0.029794	57.5	0.039864	67.5

(*2*) For consumer instantaneous water heaters:

$$UEF_{model} = \frac{\eta_r}{1 + A\eta_r}$$

Where η_r is the recovery efficiency expressed in decimal form and A is dependent upon the applicable draw pattern and fuel type as specified in the table below.

Draw pattern	A	
	Electric	Gas
Very Small	0.003819	0.026915
Low	0.001549	0.010917
Medium	0.001186	0.008362
High	0.000785	0.005534

(*3*) For residential-duty commercial storage water heaters:

$$UEF_{rd} = \left[\frac{1}{E_t} + F * SL\left(G - \frac{1}{P\ E_t}\right)\right]^{-1}$$

Where P is the input rate in Btu/h; Et is the thermal efficiency; SL is the standby loss in Btu/h; and F and G are coefficients as specified in the table below based on the applicable draw pattern.

Draw pattern	F	G
Very Small	0.821429	0.0043520
Low	0.821429	0.0011450
Medium	0.821429	0.0007914
High	0.821429	0.0005181

(*4*) For residential-duty commercial electric instantaneous water heaters:

$$UEF_{rd,model} = \frac{E_t}{1 + AE_t}$$

Where E_t is the thermal efficiency expressed in decimal form and A is dependent upon the applicable draw pattern, as specified in the table below.

Draw pattern	A
Very Small	0.003819
Low	0.001549
Medium	0.001186
High	0.000785

(b) *Certification reports.*

(1) The requirements of 10 CFR 429.12 apply; and

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

(i) For storage-type water heater basic models previously certified for energy factor pursuant to § 429.17(a) of the January 1, 2015 edition of the Code of Federal Regulations, and for which uniform energy factor is calculated pursuant to 10 CFR 429.17(a)(2)(ii): The energy factor (EF, rounded to the nearest 0.01), the uniform energy factor (UEF, rounded to the nearest 0.01), the rated storage volume in gallons (gal, rounded to the nearest 1 gal), the uniform energy factor test procedure first-hour rating in gallons (gal, rounded to the nearest 1 gal) as determined under paragraph (a)(2)(ii)(A) of this section, the previously certified first-hour rating under the energy factor test procedure in gallons (gal, rounded to the nearest 1 gal), and the recovery efficiency in percent (%, rounded to the nearest 1%);

(ii) For storage-type water heater basic models rated pursuant to 10 CFR 429.17(a)(1) or 10 CFR 429.17(a)(2)(i): The uniform energy factor (UEF, rounded to the nearest 0.01), the rated storage volume in gallons (gal, rounded to the nearest 1 gal), the first-hour rating in gallons (gal, rounded to the nearest 1 gal), and the recovery efficiency in percent (%, rounded to the nearest 1%);

(iii) For instantaneous-type water heater basic models previously certified for energy factor pursuant to § 429.17(a) of the January 1, 2015 edition of the Code of Federal Regulations, and for which uniform energy factor is calculated pursuant to 10 CFR 429.17(a)(2)(ii): The energy factor (EF, rounded to the nearest 0.01), the uniform energy factor (UEF. rounded to the nearest 0.01), the rated storage volume in gallons (gal, rounded to the nearest 1 gal), the uniform energy factor test procedure maximum gallons per minute (gpm, rounded to the nearest 0.1 gpm) as determined under-paragraph (a)(2)(ii)(A) of this section, the previously certified maximum gallons per minute (gpm, rounded to the nearest 0.1 gpm) under the energy factor test procedure, and the recovery efficiency in percent (%, rounded to the nearest 1%); and

(iv) For instantaneous-type water heater basic models rated pursuant to 10 CFR 429.17(a)(1) or 10 CFR 429.17(a)(2)(i): The uniform energy factor (UEF, rounded to the nearest 0.01), the rated storage volume in gallons (gal, rounded to the nearest 1 gal), the maximum gallons per minute (gpm, rounded to the nearest 0.1 gpm), and the recovery efficiency in percent (%, rounded to the nearest 1%).(the uniform energy factor test procedure first-hour rating in gallons (gal, rounded to the nearest 1 gal) as determined under paragraph (a)(2)(ii)(A) of this section,

(v) For grid-enabled water heater basic models rated pursuant to 10 CFR 429.17(a)(1) or 10 CFR 429.17(a)(2)(i): The uniform energy factor (UEF, rounded to the nearest 0.01), the rated storage volume in gallons (gal, rounded to the nearest 1 gal), the first-hour rating in gallons (gal, rounded to the nearest 1 gal), and the recovery efficiency in percent (%, rounded to the nearest 1%), a declaration that the model is a grid-enabled water heater, whether it is equipped at the point of manufacture with an activation lock, and whether it bears a permanent label applied by the manufacturer that advises purchasers and end-users of the intended and appropriate use of the product.

3. Section 429.17 is further revised, proposed to be effective (*date one year after publication of test procedure 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 i^{th} sample;

Or,

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

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

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).

(B) Any represented value of the uniform 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, x is the sample mean; n is the number of samples; and x_i is the i^{th} sample;

Or,

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

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

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).

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

(D) 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: The uniform energy factor (UEF, rounded to the nearest 0.01), the rated storage volume in gallons (rounded to the nearest 1 gal), the first-hour rating in gallons (gal, rounded to the nearest 1 gal), the recovery efficiency in percent (%, rounded to the nearest 1%);

(ii) For instantaneous-type water heater basic models: The uniform energy factor (UEF, rounded to the nearest 0.01), the rated storage volume in gallons (gal, rounded to the nearest 1 gal), the maximum gallons per minute (gpm, rounded to the nearest 0.1 gpm), the recovery efficiency in percent (%, rounded to the nearest 1%); and

(iii) For grid-enabled water heater basic models: The uniform energy factor (UEF, rounded to the nearest 0.01), the rated storage volume in gallons (gal, rounded to the nearest 1 gal), the first-hour rating in gallons (gal, rounded to the nearest 1 gal), the recovery efficiency in percent (%, rounded to the nearest 1%), a declaration that the model is a grid-enabled water heater, whether it is equipped at the point of manufacture with an activation lock, and whether it bears a permanent label applied by the manufacturer that advises purchasers and end-users of the intended and appropriate use of the product.

■ 4. Section 429.44 is amended by revising paragraph (d) [proposed at 81 FR 28588, 28636 (May 9, 2016)] to read as follows:

§ 429.44 Commercial water heating equipment.

* * * * *

(d) *Certification reports for residential-duty commercial water heaters.*

(1) The requirements of § 429.12 apply; and

(2) Pursuant to § 429.12(b)(13), a certification report must include the following public equipment-specific information:

(i) Residential-duty commercial gas-fired and oil-fired storage water heaters previously certified for thermal efficiency and standby loss pursuant to 10 CFR 429.44(b) of the January 1, 2015 edition of the Code of Federal Regulations, and for which uniform energy factor is calculated pursuant to 10 CFR 429.17(a)(2)(ii): The thermal efficiency in percent (%), the standby loss in British thermal units per hour (Btu/h), the uniform energy factor (UEF, rounded to the nearest 0.01), the rated storage volume in gallons (gal), and the nameplate input rate in Btu/h.

(ii) Residential-duty commercial gas-fired and oil-fired storage water heaters rated for uniform energy factor pursuant to 10 CFR 429.17(a)(2)(i): The uniform energy factor (UEF, rounded to the nearest 0.01), the rated storage volume in gallons (rounded to the nearest 1 gal), the first-hour rating in gallons (gal, rounded to the nearest 1 gal), and the recovery efficiency in percent (%, rounded to the nearest 1%).

(iii) Residential-duty commercial electric instantaneous water heaters previously certified for thermal efficiency and standby loss pursuant to 10 CFR 429.44(b) of the January 1, 2015 edition of the Code of Federal Regulations, and for which uniform energy factor is calculated pursuant to 10 CFR 429.17(a)(2)(ii): The thermal efficiency in percent (%), the standby loss in British thermal units per hour (Btu/h), the uniform energy factor (UEF, rounded to the nearest 0.01), the rated storage volume in gallons (gal), and the nameplate input rate in kilowatts (kW).

(iv) Residential-duty commercial electric instantaneous water heaters rated for uniform energy factor pursuant to 10 CFR 429.17(a)(2)(i): The uniform energy factor (UEF, rounded to the nearest 0.01), the rated storage volume in gallons (gal, rounded to the nearest 1 gal), the maximum gallons per minute (gpm, rounded to the nearest 0.1 gpm), and the recovery efficiency in percent (%, rounded to the nearest 1%)).

* * * * *

■ 5. Section 429.44 is further amended, proposed to be effective (*date one year after publication of test procedure final rule*), by revising paragraph (d)(2) to read as follows:

§ 429.44 Commercial water heating equipment.

* * * * *

(d) * * *

(2) Pursuant to § 429.12(b)(13), a certification report for equipment must include the following public equipment-specific information:

(i) Residential-duty commercial gas-fired and oil-fired storage water heaters: The uniform energy factor (UEF, rounded to the nearest 0.01), the rated storage volume in gallons (gal, rounded to the nearest 1 gal), the first-hour rating in gallons (gal, rounded to the nearest 1 gal), and the recovery efficiency in percent (%, rounded to the nearest 1%).

(ii) Residential-duty commercial electric instantaneous water heaters: The uniform energy factor (UEF, rounded to the nearest 0.01), the rated storage volume in gallons (gal, rounded to the nearest 1 gal), the maximum gallons per minute (gpm, rounded to the nearest 0.1 gpm), and the recovery efficiency in percent (%, rounded to the nearest 1%).

* * * * *

■ 6. Section 429.134 is revised by amending paragraph (d)(2) to read as follows:

§ 429.134 Product-specific enforcement provisions.

* * * * *

(d) * * *

(2) *Verification of rated storage volume.* The storage volume of the basic model will be measured pursuant to the test requirements of appendix E to subpart B of 10 CFR part 430 for each unit tested. The mean of the measured values will be compared to the rated storage volume as certified by the manufacturer. The rated value will be considered valid only if the measurement is within two percent of the certified rating.

(i) If the rated storage volume is found to be within 2 percent of the mean of the measured value of storage volume, then the rated value will be used as the basis for calculation of the required uniform energy factor for the basic model.

(ii) If the rated storage volume is found to vary more than 2 percent from the mean of the measured values, then the mean of the measured values will be used as the basis for calculation of the required uniform energy factor for the basic model.

* * * * *

PART 430—ENERGY CONSERVATION PROGRAM FOR CONSUMER PRODUCTS

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

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

■ 8. 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 is calculated as—

(A) For a gas-fired or oil-fired 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. Round the resulting product 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. Round the resulting quotient to the nearest dollar per year.

(ii) For an individual unit, determine the tested energy factor in accordance with 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, and round the value to the nearest 0.01.

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

(i) The estimated annual operating cost is calculated as:

(A) For a gas-fired or oil-fired water heater, the sum of: The product of the annual gas or oil energy consumption, determined according to section 6.3.9 or 6.4.6 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 6.3.8 or 6.4.5 of appendix E of this subpart, times the representative average unit cost of electricity in dollars per kilowatt-hour as provided by the Secretary. Round the resulting sum to the nearest dollar per year.

(B) For an electric water heater, the product of the annual energy consumption, determined according to section 6.3.7 or 6.4.4 of appendix E of this subpart, times the representative average unit cost of electricity in dollars per kilowatt-hour as provided by the Secretary. Round the resulting product to the nearest dollar per year.

(ii) For an individual unit, determine the tested uniform energy factor in accordance with section 6.3.6 or 6.4.3 of appendix E of this subpart, and round the value to the nearest 0.01.

* * * * *

■ 9. Section 430.23 paragraph (e) is further revised, proposed to be effective (*date one year after publication of test procedure final rule*), to read as follows:

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

* * * * *

(e) *Water Heaters.*

(1) The estimated annual operating cost is calculated as:

(i) For a gas-fired or oil-fired water heater, the sum of: The product of the annual gas or oil energy consumption, determined according to section 6.3.9 or 6.4.6 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 6.3.8 or 6.4.5 of appendix E of this subpart, times the representative average unit cost of electricity in dollars per kilowatt-hour as provided by the Secretary. Round the resulting sum to the nearest dollar per year.

(ii) For an electric water heater, the product of the annual energy consumption, determined according to section 6.3.7 or 6.4.4 of appendix E of this subpart, times the representative average unit cost of electricity in dollars per kilowatt-hour as provided by the Secretary. Round the resulting product to the nearest dollar per year.

(2) For an individual unit, determine the tested uniform energy factor in accordance with section 6.3.6 or 6.4.3 of appendix E of this subpart, and round the value to the nearest 0.01.

* * * * *

■ 10. 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 uniform energy factor of water heaters shall not be less than the following:

Product class	Rated storage volume and input rating (if applicable)	Draw pattern	Uniform energy factor
Gas-fired Storage Water Heater	<20 gal	Very Small	0.2471–(0.0002 x V_r).
		Low	0.5132–(0.0012 x V_r).
		Medium	0.5827–(0.0015 x V_r).
		High	0.6507–(0.0019 x V_r).
	≥20 gal and ≤55 gal	Very Small	0.3456–(0.0020 x V_r).
		Low	0.5982–(0.0019 x V_r).
		Medium	0.6483–(0.0017 x V_r).
		High	0.6920–(0.0013 x V_r).
	>55 gal and ≤100 gal	Very Small	0.6470–(0.0006 x V_r).
		Low	0.7689–(0.0005 x V_r).
		Medium	0.7897–(0.0004 x V_r).
		High	0.8072–(0.0003 x V_r).
	>100 gal	Very Small	0.1755–(0.0006 x V_r).
		Low	0.4671–(0.0015 x V_r).
		Medium	0.5719–(0.0018 x V_r).
		High	0.6916–(0.0022 x V_r).
Oil-fired Storage Water Heater	≤50 gal	Very Small	0.1822–(-0.0001 x V_r).
		Low	0.5313–(0.0014 x V_r).
		Medium	0.6316–(0.0020 x V_r).
		High	0.7334–(0.0028 x V_r).
	>50 gal	Very Small	0.1068–(0.0007 x V_r).
		Low	0.4190–(0.0017 x V_r).
		Medium	0.5255–(0.0021 x V_r).
		High	0.6438–(0.0025 x V_r).
Electric Storage Water Heaters	<20 gal	Very Small	0.7836–(0.0013 x V_r).
		Low	0.8939–(0.0008 x V_r).
		Medium	0.9112–(0.0007 x V_r).
		High	0.9255–(0.0006 x V_r).
	≥20 gal and ≤55 gal	Very Small	0.8808–(0.0008 x V_r).
		Low	0.9254–(0.0003 x V_r).

Product class	Rated storage volume and input rating (if applicable)	Draw pattern	Uniform energy factor
		Medium	0.9307–(0.0002 x V_r).
		High	0.9349–(0.0001 x V_r).
	>55 gal and ≤120 gal	Very Small	1.9236–(0.0011 x V_r).
		Low	2.0440–(0.0011 x V_r).
		Medium	2.1171–(0.0011 x V_r).
		High	2.2418–(0.0011 x V_r).
	>120 gal	Very Small	0.6802–(0.0003 x V_r).
		Low	0.8620–(0.0006 x V_r).
		Medium	0.9042–(0.0007 x V_r).
		High	0.9437–(0.0007 x V_r).
Tabletop Water Heater	All	Very Small	0.6323–(0.0058 x V_r).
		Low	0.9188–(0.0031 x V_r).
		Medium	0.9577–(0.0023 x V_r).
		High	0.9884–(0.0016 x V_r).
Instantaneous Gas-fired Water Heater	<2 gal and >50,000 Btu/h	Very Small	0.7964–(0.0000 x V_r).
		Low	0.8055–(0.0000 x V_r).
		Medium	0.8070–(0.0000 x V_r).
		High	0.8086–(0.0000 x V_r).
	≥2 gal or ≤50,000 Btu/h	Very Small	0.3013–(0.0023 x V_r).
		Low	0.5421–(0.0024 x V_r).
		Medium	0.5942–(0.0021 x V_r).
		High	0.6415–(0.0017 x V_r).
Instantaneous Oil-fired Water Heater	All	Very Small	0.1430–(0.0015 x V_r).
		Low	0.4455–(0.0023 x V_r).
		Medium	0.5339–(0.0023 x V_r).
		High	0.6245–(0.0021 x V_r).
Instantaneous Electric Water Heater	All	Very Small	0.9161–(0.0039 x V_r).
		Low	0.9159–(0.0009 x V_r).
		Medium	0.9160–(0.0005 x V_r).
		High	0.9161–(0.0003 x V_r).
Grid-Enabled Water Heater	>75 gal	Very Small	1.0136–(0.0028 x V_r).
		Low	0.9984–(0.0014 x V_r).
		Medium	0.9853–(0.0010 x V_r).
		High	0.9720–(0.0007 x V_r).

*V_r is the rated storage volume in gallons.

* * * * *

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

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

Authority: 42 U.S.C. 6291–6317. 28 U.S.C. 2461 note.

■ 12. Section 431.110 is amended by revising paragraph (d) [proposed at 81 FR 34440. 34536–34537 (May 31, 2016)] to read as follows:

§ 431.110 Energy conservation standards and their effective dates.

* * * * *

(d) Each residential-duty commercial water heater manufactured prior to (*date 3 years after publication in the* ***Federal Register*** *of the final rule establishing amended energy conservation standards for commercial water-heating equipment*) must meet the applicable energy conservation standard level(s) as follows:

Product class	Specifications [a]	Draw pattern	Uniform energy factor [b]
Gas-fired Storage	>75 kBtu/hr and ≤105 kBtu/hr and ≤120 gal	Very Small	0.2670 − (0.0009 × V_r)
		Low	0.5356 − (0.0012 × V_r)
		Medium	0.5996 − (0.0011 × V_r)
		High	0.6592 − (0.0009 × V_r)
Oil-fired Storage	>105 kBtu/hr and ≤140 kBtu/hr and ≤120 gal	Very Small	0.2932 − (0.0015 × V_r)
		Low	0.5596 − (0.0018 × V_r)
		Medium	0.6194 − (0.0016 × V_r)
		High	0.6740 − (0.0013 × V_r)
Electric Instantaneous	>12 kW and ≤58.6 kW and ≤2 gal	Very Small	0.80
		Low	0.80
		Medium	0.80
		High	0.80

[a] Additionally, to be classified as a residential-duty commercial water heater, a commercial water heater must meet the following conditions: (1) If the water heater requires electricity, it must use a single-phase external power supply; and (2) the water heater must not be designed to heat water to temperatures greater than 180 °F.
[b] V_r is the rated storage volume in gallons.

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