DEPARTMENT OF ENERGY

Office of Energy Efficiency and Renewable Energy

10 CFR Part 430

[Docket Number EE–RM–97–900]

RIN 1904–AA76

Energy Conservation Program for Consumer Products: Energy Conservation Standards for Water Heaters

AGENCY: Office of Energy Efficiency and Renewable Energy, Department of Energy (DOE).

ACTION: Notice of proposed rulemaking and public workshop.

SUMMARY: The Energy Policy and Conservation Act, as amended, prescribes energy conservation standards for certain major household appliances, and requires the Department of Energy (DOE) to administer an energy conservation program for these products. In this notice we are proposing to amend the energy conservation standards for water heaters to make them more efficient and announce a public hearing.

DATES: Comments must be received on or before July 12, 2000. DOE is requesting a signed original, a computer disk (WordPerfect 8) and 10 copies of the written comments. The Department will also accept e-mailed comments, but you must also send a signed original. Oral views, data, and arguments may be presented at the public workshop (hearing) in Washington, DC, beginning at 9:00 a.m. on June 20, 2000.

The Department must receive requests to speak at the workshop and a copy of your statements no later than 4:00 p.m., June 6, 2000, and we request that you provide a computer diskette (WordPerfect 8) of each statement at that time. The DOE panel will read the statements in advance of the workshop and requests that speakers limit their oral presentations to a summary. Attendees will have an opportunity to ask questions.

ADDRESSES: Please submit written comments, oral statements, and requests to speak at the workshop to Brenda Edwards-Jones, U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy, Energy Conservation Program for Consumer Products: Water Heaters, Docket Number EE–RM–97–900, 1000 Independence Avenue, SW, Rm 1J018, Washington, DC 20585–0121. You may send email to: brenda.edwards-jones@ee.doe.gov. The workshop will begin at 9:00 a.m., in Room 1E–245 at the U.S. Department of Energy, Forrestal Building, 1000 Independence Avenue, SW, Washington, DC. You can find more information concerning public participation in this rulemaking proceeding in Section VI, ''Public Comment Procedures,'' of this notice of proposed rulemaking.

You may read copies of the public comments, the Technical Support Document for Energy Efficiency Standards for Consumer Products: Water Heaters (TSD) and the transcript of the public hearing and previous workshop transcripts at the DOE Freedom of Information (FOI) Reading Room, U.S. Department of Energy, Forrestal Building, Room 1E–190, 1000 Independence Avenue, SW, Washington, DC 20585, (202) 586–3142, between the hours of 9:00 a.m. and 4:00 p.m., Monday through Friday, except Federal holidays. You may obtain copies of the TSD and analysis spreadsheets from the Office of Energy Efficiency and Renewable Energy's (EERE) web site at http://www.eren.doe.gov/buildings/codes_standards/applbrf/waterheater.htm.

FOR FURTHER INFORMATION CONTACT:
Terry Logee, U.S. Department of Energy, EE–41, 1000 Independence Avenue, SW, Washington, DC 20585–0121, (202) 586–9127, email: terry.logee@ee.doe.gov or Francine Pinto, Esq., U.S. Department of Energy, Office of General Counsel, GC–72, 1000 Independence Avenue, SW, Washington, DC 20585, (202) 586–7432, email: francine.pinto@hq.doe.gov or Eugene Margolis, Esq., GC–72, at the same address, (202) 586–9507, email: eugene.margolis@hq.doe.gov.

SUPPLEMENTARY INFORMATION:

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I. Summary of Proposed Rule

The Energy Policy and Conservation Act, as amended (hereinafter referred to as EPCA or the Act), specifies that any new or amended energy conservation standard the Department of Energy (DOE) prescribes shall be designed to ''achieve the maximum improvement in energy efficiency . . . which the Secretary determines is technologically feasible and economically justified.'' Section 325(o)(2)(A), 42 U.S.C. 6295(o)(2)(A). Furthermore, the amended standard must ''result in significant conservation of energy.'' Section 325(o)(2)(B)(3)(B), 42 U.S.C. 6295(o)(2)(B)(3)(B).

In accordance with the statutory criteria discussed in this notice, DOE is proposing to amend the water heater energy efficiency standards. The proposed standards represent performance consistent with:

- electric water heaters with heat traps, 2.5 inches of insulation and an insulated tank bottom;
- gas-fired water heaters with heat traps, flue baffles that achieve a 78% recovery efficiency (RE) and 2 inches of insulation;
- no change from the current standard for oil-fired water heaters.

The proposed standard, trial standard level three, is based on using HFC–245fa as a blowing agent in the insulation and saves an estimated 4.75 quads of energy over 27 years, a significant amount. This amount is more than the primary energy used for heating water in all U.S. buildings (residential, commercial and industrial) in 1997 (3.82 quads). The economic impacts on consumers (i.e., the average life-cycle cost (LCC) savings) are positive. We identified and conducted analyses on two subgroups of the population, senior-only and low income consumers, because of concern that these groups might potentially be affected differently by the standards than the rest of the population. Our analyses showed no difference.

The national net present value (NPV) of trial standard level three is $3.4 billion from 2003–2030. This is the estimated total value of future savings discounted to 1998 minus the estimated increased equipment costs also discounted to 1998. The water heater industry net present value (INPV) today is estimated to be $322 million. If we adopt trial standard level three, we expect manufacturers may lose 5 percent of the INPV, which is approximately $15 million. Other government actions that require the phase out of HCFC–141b and the prevention of ignition of flammable vapors by gas-fired water heaters will result in losses of an estimated $28 million in INPV. The cumulative effects of all government actions is an estimated loss of $43 million of INPV, or about 13 percent. However, the present value of future energy savings for the U.S. are projected to be $3.4 billion. These substantial energy savings exceed industry losses due to energy efficiency standards by 227 times or, due to all Federal actions, by 79 times. Additionally, based on our interviews with four of the five major manufacturers, we do not expect any plant closings or loss of employment because the manufacturers stated that they would stay in business. During the interviews, the manufacturers all stated that only trial standard level four (incorporating plastic tanks and side-arm heaters) would severely impact employment levels and require new facilities.

The proposed standard has significant environmental benefits, addressing global climate change and reducing air pollution. This proposed standard level would result in cumulative greenhouse gas emission reductions of 83 million metric tons (Mt) of carbon equivalent. Additionally, air pollution would be reduced by the elimination of 229 thousand metric tons of nitrous oxides (NO_X) from 2003–2030.

Trial standard level three has several other benefits. First, it maximizes the LCC savings to consumers, which means that total consumers' benefits are higher as a result of this standard level than any of the other standard levels analyzed. Second, this trial standard level causes similar cost increases between gas-fired and electric water heaters so the impacts in the market are fuel neutral.

Therefore, DOE has determined that the benefits to the nation outweigh the burdens and we conclude that trial standard level three is economically justified. Furthermore, DOE has determined that trial standard level three is technologically feasible. The design options incorporated in trial standard level three are commercially available on some models of electric and gas-fired heaters sold in the U.S.

II. Introduction

A. Authority

Part B of Title III of the Energy Policy and Conservation Act, Pub.L. 94–163, as amended by the National Energy Conservation Policy Act, Pub.L. 95–619, the National Appliance Energy Conservation Act, Pub.L. 100–12, the National Appliance Energy Conservation Amendments of 1988, Pub.L. 100–357, and the Energy Policy Act of 1992, Pub.L. 102–486, created the Energy Conservation Program for Consumer Products other than Automobiles. Water heaters are one of the consumer products subject to this program. Section 322(a)(4), 42 U.S.C. 6292(a)(4).

Under the Act, the program consists essentially of three parts: testing, labeling, and Federal energy conservation standards. The Department, with assistance from the National Institute of Standards and Technology (NIST), may amend or establish test procedures for each of the covered products. Section 323(b)(1)(A)–(B), 42 U.S.C. 6293(b)(1)(A)–(B). The test procedures measure the energy efficiency, energy use, or estimated annual operating cost of a covered product during a representative average use cycle or period of use. They must not be unduly burdensome to conduct. Section 323(b)(3), 42 U.S.C. 6293(b)(3). A test procedure is not required if DOE determines by rule that one cannot be developed. Section 323(d)(1), 42 U.S.C. 6293(d)(1). The water heater test procedures appear at Title 10 Code of Federal Regulations (CFR) part 430, subpart B, appendix E.

The Act prescribes an initial Federal energy conservation standard for each of the listed covered products, except television sets. The Department is authorized to amend these standards. Section 325, 42 U.S.C. 6295. Any new or amended standard must be designed to achieve the maximum improvement in energy efficiency that is technologically feasible and economically justified. Section 325(o)(2)(A), 42 U.S.C. 6295(o)(2)(A). The Department's current review of standards is for water heaters. Section 325(e), 42 U.S.C. 6295(e).

Section 325(o)(2)(B)(i), 42 U.S.C. 6295(o)(2)(B)(i) provides that before DOE determines whether a standard is economically justified, it must first ask for comments on a proposed standard. After reviewing comments on the proposal, DOE must determine that the benefits of the standard exceed its burdens, based, to the greatest extent practicable, on a weighing of the following seven factors:

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

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

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

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

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

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

(7) Other factors the Secretary considers relevant.

In addition, Section 325(o)(2)(B)(iii), 42 U.S.C. 6295(o)(2)(b)(iii), establishes a rebuttable presumption of economic justification in instances where the Secretary determines that ''the additional cost to the consumer of purchasing a product complying with an energy conservation standard level will be less than three times the value of the energy, and as applicable, water, savings during the first year that the consumer will receive as a result of the standard, as calculated under the applicable test procedure . . .'' The rebuttable presumption test is an alternative path to establishing economic justification.

Section 327 of the Act, 42 U.S.C. 6297, addresses the effect of Federal rules on State laws or regulations concerning testing, labeling, and standards. Generally, all such State laws or regulations are superseded by the Act, unless specifically exempted in Section 327. The Department can grant a waiver of preemption in accordance with the procedures and other provisions of Section 327(d) of the Act. 42 U.S.C. 6297(d).

B. Background

1. Current Standards

The existing water heater efficiency standards have been in effect since 1991. Energy efficiency is measured in terms of an energy factor (EF), which measures overall water heater efficiency and is determined by the DOE test procedure. 10 CFR part 430, subpart B, appendix E. The water heater efficiency standards are as follows:

- electric, EF = 0.93—(0.00132 x rated volume)
- gas-fired, EF = 0.62—(0.0019 x rated volume)
- oil-fired, EF = 0.59—(0.0019 x rated volume)

where rated volume is the water storage capacity of a water heater in gallons, as specified by the manufacturer.

2. History of Previous Rulemakings

On September 28, 1990, DOE published an Advance Notice of Proposed Rulemaking (ANOPR) announcing the Department's intention to revise the existing water heater efficiency standard. (55 FR 39624). On March 4, 1994, DOE proposed a rule to revise the energy conservation standards for water heaters, as well as a variety of other consumer products. (59 FR 10464). On January 31, 1995, we published a determination that we would issue a revised notice of proposed rulemaking (NOPR) for water heaters. (60 FR 5880). This is the revised proposal for amending the energy efficiency standards for water heaters.

3. Process Improvement

The fiscal year (FY) 1996 appropriations legislation imposed a moratorium on proposed or final rules for appliance efficiency standards for FY 1996. Pub. L. 104–134. During the moratorium, the Department examined the appliance standards program and how it was working. Congress advised DOE to correct the standards-setting process and to bring together stakeholders (such as manufacturers and environmentalists) for assistance. Therefore, we consulted with energy efficiency groups, manufacturers, trade associations, state agencies, utilities and other interested parties to provide input to the process used to develop appliance efficiency standards. As a result, on July 15, 1996, the Department published a Final Rule: Procedures for Consideration of New or Revised Energy Conservation Standards for Consumer Products (referred to as the Process Rule) (61 FR 36974), codified at 10 CFR part 430, subpart C, appendix A.

The Process Rule states that for products, such as water heaters, for which DOE issued a NOPR prior to August 14, 1996, DOE will conduct a review to decide whether any of the analytical or procedural steps already completed should be repeated. (61 FR 36982). DOE completed this review and decided to use the Process Rule, to the extent possible, in the development of the revised water heater standards.

We developed an analytical framework for the water heater standards rulemaking for our stakeholders, which we presented during a water heater workshop on June 24, 1997. The analytical framework described the different analyses (e.g., LCC, payback and manufacturing impact analyses (MIA)) to be conducted, the method for conducting them, the use of new LCC and national energy savings (NES) spreadsheets, and the relationship between the various analyses.

4. Test Procedures

The DOE test procedure determines the water heater EF, which is a measure of overall water heater efficiency. Two other water heater performance characteristics determined by the DOE test procedures are the overall heat transfer coefficient (UA) and the recovery efficiency (RE) for gas and oil-fired water heaters. The UA is referred to as the standby heat loss coefficient of the storage tank. It is a measure of the amount of heat in British thermal units (Btus) lost from a water heater in one hour. The RE is defined as the ratio of energy delivered to the water to the energy content of the fuel consumed by the water heater.

The Act does not allow DOE to set energy standards for a product unless there is a test procedure. The Department published a test procedure on May 11, 1998, that revised the first-hour rating of storage-type water heaters, added a new rating for electric and gas-fired instantaneous water heaters and amended the definition of a heat pump water heater. (63 FR 25996). This revision did not change the test method for determining energy efficiency standards.

III. Analysis and Methodology

This section describes the analyses and methodologies to be used in this rulemaking. It includes a general introduction to each analysis section and provides a discussion of issues relative to the water heater rule (see Chapter 2 of the TSD).

A. Market and Technology Assessment

The market and technology assessment characterizes the relevant product markets and existing technology options including prototype designs.

1. General

When initiating a standards rulemaking, the Department develops information on the present and past industry structure and market characteristics of the product(s) concerned. This activity consists of both quantitative and qualitative efforts to assess the industry and products based on publicly available information. Issues to be addressed include: (1) manufacturer market share and characteristics; (2) trends in the number of firms; (3) the financial situation of manufacturers; (4) existing non-regulatory efficiency improvement initiatives; and (5) trends in product characteristics and retail markets. The information collected serves as resource material to be used throughout the rulemaking.

2. Product Specific

There are five major manufacturers in the residential water heater market. We estimate they have the following market shares as of 1997: Bradford White 10%, American and AO Smith 16% each, Rheem 28% and State Industries 29%; all others add up to 1%. Annual residential water heater shipments (i.e., the total number of water heaters delivered to and installed in consumers' homes) have gradually increased from 7.4 million units in 1987 to 9.1 million units per year in 1997.

Financial information for most water heater manufacturers is not publicly available, with only one publicly traded water heater manufacturer in the United States. Information from the U.S. Census Bureau Current Industrial Reports for 1997 and other public sources shows industry shipments with a value of $1.3 billion for 9.1 million water heaters. Typical industry profits are 6 percent of revenues.

There is no current national non-regulatory water heater efficiency improvement program. However, DOE is considering an Energy Star® water heater program and currently is supporting a program to demonstrate a 50 gallon, 6,000 Btu input heat pump water heater and to develop a residential condensing gas-fired water heater. If successful, the DOE heat pump water heater program will eliminate the installation, service and some of the product utility issues that formed most of our basis for screening out heat pump water heaters. This DOE heat pump water heater is designed to be a ''drop-in'' replacement for a standard electric water heater. Therefore it requires only standard plumbing and wiring connections and it will fit in most electric water heater closets. However, it still will not fit under counters or in spaces less than four feet tall.

In addition, the Federal Energy Management Program's (FEMP) ''Buying Energy Efficient Products Program'' identifies the upper 25% energy efficient residential gas and electric water heaters. These levels are recommended to Federal agencies with the ultimate goal of moving the entire U.S. market toward higher energy efficiency. We are aware of a few gas and electric utility programs that encourage the use of higher efficiency water heaters, including consumer rebates or dealer incentive programs, financing, consumer education, and rental/guarantee programs that often include installation and maintenance costs. In the past decade, the number of these utility programs has diminished considerably due to restructuring of the electric and gas utility industries.

The water heater market is largely a replacement market, accounting for 80–85% of sales. The remaining 15–20% of sales are for new installations. Of the 9.1 million water heaters sold annually, we estimate plumbing wholesalers sell approximately 4.3 million, while retail outlets such as Sears, Wards, Home Depot, and Lowes sell the majority of the remaining 4.8 million. Characteristics of the replacement market include: (1) consumers typically replace the existing water heater with one of similar fuel and capacity; (2) consumers consider the ease of installation—it has to fit in the existing space; (3) consumers usually replace water heaters under emergency conditions when they fail; and (4) consumers typically ask for and follow the installers' recommendations.

Residential water heating uses about 2.6 quads per year of primary energy out of 19 quads (year 1997) for all residential buildings, at a cost of $26.4 billion. Where natural gas is available, 74% of households use gas to heat water and 24% heat with electric. Where gas is not available, 84% of households use electric water heaters and the remaining households use oil-fired water heaters or liquid petroleum gas (LPG).

B. Technological Feasibility

Under the guidelines in the Process Rule, DOE will eliminate from consideration, early in the process, any design options that present unacceptable problems with respect to technological feasibility, practicability to manufacture, install, and service, product utility or unavailability, or safety. In order to conduct the screening analysis, the Department gathers information regarding all current technology options and prototype designs. In consultation with interested parties, the Department develops a list of design options for consideration in the rulemaking. All technologically feasible design options are candidates in this initial assessment. We identified heat pump water heaters and gas condensing water heaters as the maximum technologically feasible designs based on measured EF's greater than 2.0 and 0.9, respectively.

The Department considers design options technologically feasible if they are already in use by the respective industry or research has progressed to the development of a working prototype. The Process Rule sets forth a definition of technological feasibility as follows: ''Technologies incorporated in commercial products or in working prototypes will be considered technologically feasible.'' 10 CFR 430, subpart C, appendix A(4)(a)(4)(i).

The Department has determined that all of the design options discussed in today's notice are technologically feasible as required by Section 325(o)(2)(A) of EPCA, as amended.

C. Screening Analysis

Screening identifies those design options the Department will consider in the engineering analysis. This includes all technologically feasible design options not eliminated in the screening analysis. The screening analysis provides a basis for eliminating certain problematic design options from further consideration early in the process. Initially, the candidate design options encompass all those technologies considered to be commercially available or in working prototypes. The Process Rule establishes the factors DOE uses for screening design options. The factors are as follows:

- Technological feasibility. DOE will only consider technologies that are incorporated in commercially available products or in working prototypes.
- Practicability to manufacture, install, and service. A technology must be able to be mass produced, installed and serviced on a scale that will serve the relevant market at the time of the effective date of the standard.
- Impacts on product utility to consumers. DOE must determine if any energy efficiency designs have significant adverse impacts on product utility, including impacts on significant subgroups of consumers, or if a product would become unavailable with performance characteristics that are substantially the same as products presently available in the U.S.

• Adverse impacts on health and/or safety. DOE will not consider any designs that have significant adverse impacts on health or safety.

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

1. Product Classes

DOE divides water heaters into classes based on the type of fuel used to heat water: electricity, natural gas/LPG, and oil. Different energy efficiency standards will apply to different product classes. DOE defines residential storage water heaters in the following classes:

• An electric water heater has a storage capacity of 20–120 gallons and a heat input of 12 kilowatt (kW) or less.

• A gas-fired water heater has a storage capacity of 20–100 gallons and a heat input of 75,000 Btu per hour or less.

• An oil-fired water heater has a storage capacity of 50 gallons or less and a heat input of 105,000 Btu per hour or less.

2. Baseline Units

In order to analyze design options for energy efficiency improvements, the Department defines a baseline unit. For each product class, the baseline unit is one that meets the existing standard. We determined the following baseline units for each fuel type:

• The baseline electric water heater is a 50-gallon glass-lined steel tank with 1.5 inch polyurethane foam insulation and two 4,500 watt heater elements. The baseline EF is 0.86.

• The baseline gas water heater is a 40-gallon glass-lined steel tank with a nominal 4 inch center flue. The heat input rate is 40,000 Btu/hr with a 450 Btu/hr pilot light. The tank is insulated with 1 inch of polyurethane foam. The energy factor is 0.54 and the recovery efficiency is 76%.

• The baseline oil-fired water heater is a 32 gallon glass-lined steel tank insulated with 1 inch of polyurethane foam. The heat input rate is 90,000 Btu/hr and it has a center flue. It has an EF of 0.53 and the RE is 75%.

3. Screening of Design Options

In the water heater rulemaking analysis, DOE considered three categories of design options: designs that reduce standby losses, designs that improve combustion efficiency, and designs that improve system efficiency. For a complete description of these design options, see Chapter 4.2 in the TSD.

a. Design Options That Reduce Standby Losses

Some designs that reduce standby losses—heat traps and increased jacket insulation—are frequently applicable to all fuel types. A heat trap is a device that keeps hot water from circulating into a piping distribution system because of natural convection. Manufacturers insulate water heaters by filling the cavity between the jacket and the tank with polyurethane foam insulation. Most water heaters on the market today have at least 1 inch thick foam insulation, while some models have 2- or 3-inch thick insulation. An alternate way to reduce jacket heat losses is to use advanced insulation materials such as evacuated panels.

The following design options reduce standby losses, but usually are restricted to one type of fuel:

• Plastic water heater tanks reduce conducted heat. This design option is used with electric water heaters or with indirect water heating techniques.

• A manufacturer can insulate the bottom of the tank, but this design option can be used only with electric water heaters or with gas or oil-fired burners mounted beside the water tank and using a heat exchanger to transfer heat to the water.

• A damper installed either at the flue exit or in the vent pipe of gas water heaters minimizes off-cycle heat losses.

• The side-arm heater design avoids flue losses by using a small, separate heat exchanger to heat water and a small circulation pump on gas-fired water heaters.

• An electronic ignition device can replace a standing pilot ignition system in gas-fired water heaters.

b. Design Options That Improve Combustion Efficiency

DOE considered six design options that improve combustion efficiency. Four design options are applicable for gas-fired and three for oil-fired water heaters:

• First, increased heat exchange from a flue baffle, multiple flues, or submerged combustion improves heat transfer. The flue baffle is a twisted strip of metal inserted into the flue of a gas or oil-fired water heater that improves heat transfer to the flue. Increased heat exchanger surface area, usually from multiple flues, improves the heat transfer from the flue gas to the water. In submerged combustion or direct-fired combustion systems for gas-fired water heaters, water is heated by direct contact with the flue products.

• Second, a condensing gas-fired water heater condenses some of the water vapor in the flue gas and extracts more heat.

• Third, an inverted U-shaped flue increases recovery efficiency and reduces standby losses of oil-fired water heaters.

• Fourth, a thermophotovoltaic or thermoelectronic generator uses silicon photovoltaic cells (energized by heat or light from the burning fuel) to generate power to run a fan and operate the electronic ignition and controls on a gas-fired water heater. This is more efficient because it eliminates the standing pilot and does not require any connection to an outside electric power source.

• Fifth, the two-phase thermosiphon is a heat pipe that transfers heat from the gas burner to the storage tank.

• Sixth, the air-atomized burner (oil-fired only) uses a stream of air to atomize the oil. This improves combustion efficiency and results in less unburned fuel in the flue.

The heat pump is the only design option that improves the heating efficiency of an electric water heater. A heat pump water heater can double the EF of an electric water heater compared to a resistance type because it uses heat from the air within the house. This can cause beneficial dehumidification or unwanted overcooling. During those times when heat gains from normal household activities or from the environment are not large enough to keep the house comfortable, e.g., the winter, the house heating system must provide the makeup heat to the house.

c. Design Options That Improve System Efficiency

There are several system improvement applications:

• The timer design option limits the amount of time during the day when an electric water heater may be energized.

• The solar pre-heat technique uses solar collectors as pre-heaters for a standard electric or gas storage-type water heater.

• The drain water heat recovery system uses a heat exchanger to recover waste heat from the drain water.

• A tempering tank—an un-insulated storage tank installed in a conditioned space— raises the inlet water temperature to the ambient temperature.

• Dip-tubes that prevent the buildup of sediment on the bottom of the tank may reduce the degradation of efficiency and prolong the life of the water heater.

While system improvement features may save energy, they are typically a part of the water heater system, not the water heater. For example, the tempering tank is a separate tank that is plumbed to the water heater. Each of these designs was eliminated in the screening analysis because none is defined as a water heater in the Act. Section 321(27), 42 U.S.C. 6291(27).

4. Results of Screening Analysis

In accordance with the Process Rule, the Department conducted a screening analysis and published the results in ''Technology Assessment and Screening Analysis,'' Appendix B: Supplement to the Water Heater Rulemaking Framework, January 1998. DOE notified stakeholders of the availability of this document in the **Federal Register** on January 14, 1998. (63 FR 2186).

We received many comments on the elimination of the heat pump water heater as a design option. Several stakeholders commented that DOE should consider all design options, including heat pump water heater designs. (American Gas Association (AGA), No. 28 at 4; Okaloosa, No. 29 at 1; Clearwater, No. 30 at 1; Mesa, No. 34 at 1; Barley, No. 32 at 1; 13 Letters from Various Gas Utilities, No. 31 at 1; and Laclede, No. 47 at 2).

DOE eliminated the heat pump water heater due to issues concerning the practicability to manufacture, install, and service on the scale necessary to serve the relevant market at the time of the effective date of the standard and product utility of these units. DOE eliminated heat pump water heaters after careful consideration of the current electric resistance and heat pump water heater markets and manufacturing technology, and after applying the factors to be considered in screening design options contained in the Process Rule. 10 CFR 430, subpart C, appendix A(4)(a)(4) and (5)(b). See Chapter 4.2.2.10 in the TSD for a discussion of the heat pump water heater screening analysis.

Several other stakeholders, including Gas Appliance Manufacturers Association (GAMA), Edison Electric Institute (EEI), Southern Company (SC), and Virginia Power (VP) supported DOE's decision to screen out heat pump water heaters. (GAMA, No. 51 at 4; EEI, No. 36 at 2; SC, No. 12 at 2 and No. 42 at 1; and VP, No. 45 at 3).

Similarly, the screening criteria were applied to condensing gas-fired water heaters. DOE eliminated gas condensing water heaters because we determined they are not technologically feasible. 10 CFR 430, subpart C, appendix A(4)(a)(4) and (5)(b). See Chapter 4.2.2.10 in the TSD for a discussion of the condensing gas-fired water heater screening analysis.

a. Heat Pump Water Heaters

Practicability to Manufacture. From meetings with the water heater industry, DOE has determined that water heater manufacturers would not have the lead time necessary to ramp up heat pump water heater production to present sales levels in the three-year time frame established by the NOPR. Since the late 1970s, sales of heat pump water heaters have not exceeded 10,000 per year (<0.33% of electric water heater sales, <0.17% of all water heater sales) and presently sales of residential heat pump water heaters are less than 4,000 residential water heaters a year in categories covered by the present rulemaking. None of the five major manufacturers of residential water heaters currently have a heat pump design in their residential product line, and only two (State and Rheem) have had a heat pump water heater in their product lines in the last 10 years.

LaClede Gas commented that DOE should not screen heat pump water heaters out as a design option because DOE is presently supporting the development of a residential heat pump water heater product. (LaClede, No. 25 at 3) The heat pump water heater design being researched by DOE is an integral heat pump water heater design which uses a small compressor with 40% less heating capacity than any used in existing heat pump water heater products (and has about 25% of the heating capacity of a typical electric resistance hot water heater). This should assist in installation in smaller spaces as it will physically use smaller components (particularly the compressor and evaporator/fan system), and will likely be quieter in operation. Present designs of the DOE heat pump re-inject condensate back into the air to be re-condensed in the evaporator. DOE believes this may simplify installation, at some expense to system capacity, efficiency and dehumidification of the residence.

The integral heat pump water heater design proposed by DOE uses a 50-gallon tank, but even the small compressor and heat exchanger used in that design adds approximately a foot in height to that tank. The attached 50-gallon storage tank is sized to provide ample water for a typical day's use in most residences. Smaller tank sizes are not being proposed, as the cost effectiveness of the heat pump decreases rapidly with smaller tank sizes and characteristic lower water usage. Presently, the smallest integral heat pump water heater design available in the U.S. is an 80-gallon unit. The design proposed by DOE would still need access to the same amount of household heat any heat pump water heater would require to serve the residence load; however, the lower heat extraction rate of the DOE unit may allow for installation in locations with smaller surrounding air volume than is required for existing designs.

The unit is being developed with input from DOE, Arthur D. Little, and Oak Ridge National Laboratory and has been designed from the outset to address many of the known market barriers facing the adoption of residential heat pump water heaters. The first barrier is the high cost of heat pump water heaters due to the heat pump motor, compressor and controls. A second barrier is the more complex (and more costly) installation for heat pump water heaters. There are size, air flow, filter replacement and condensate removal considerations. Third, poor reliability of many models has caused a lack of consumer confidence. Fourth, heat pump water heaters require more maintenance. Presently, no mass market service infrastructure exists.

Preliminary field tests of the DOE design are likely to start in the spring of 2000. Larger scale utility testing is slated for late 2000 to 2001. Accelerated reliability testing is also scheduled sometime after initial field testing has resulted in a more or less stable product. If field and reliability testing are positive, limited commercial production and sales are possible by 2003. Actual production and sales would be through an existing air-conditioning equipment manufacturer who would likely purchase storage tanks from an existing water heater manufacturer. Because of the issues that have plagued heat pump water heaters in the past, DOE is requiring its partners to introduce the product cautiously, correcting problems encountered during field testing and fully testing the corrections. A market study done by Arthur D. Little projected potential sales for the DOE design up to 300,000 units per year 10 years after commercial introduction, or 7.5% of present electric water heater sales. (ADL Report #46230 to DOE).

Although most manufacturers could develop, either alone or in partnership with others, a working heat pump water heater design in the next few years, there are significant difficulties in capitalizing and building heat pump water heater manufacturing facilities to provide for the present 4 million plus electric water heater sales annually.

Manufacturers of heat pump water heaters would need to design a completely new product and build new production facilities to supply the current electric water heater market.

This market has a market volume greater than that of all room air-conditioner shipments in the U.S. (1993 DOE Report, EE–0009). In a 1994 A. D. Little report, the estimated investment cost to convert to heat pump water heaters was $750 million. Given the current levels of profitability of the water heater industry and the limited capital resources, some manufacturers will not be able to finance these costs. (Dieckmann, Topping and Shorey, August 31, 1994, ADL Report to GAMA, ''Technical Analysis of the Proposed DOE Heat Pump Water Heater Energy Efficiency Standard'')

In addition, given the high initial cost for heat pump water heaters, poor reliability with past heat pump water heater designs, and anticipated impact on consumer utility, initial sales of electric water heaters after a heat pump water heater standard may be low as consumers look for other alternatives. With a government imposed time frame for shifting all production to heat pump water heaters and a shifting market size, it is unclear how the electric water heater industry could plan and secure investments to satisfy an unknown final market volume.

Considering these issues with regard to manufacturability and achieving sufficient production volume, DOE has concluded that the screening criterion of practicability to manufacture, on the scale necessary to serve the relevant market at the time of the effective date of the standard, will not be met.

Practicability to Install. Based on our analysis of current heat pump water heater designs and the DOE drop-in heat pump water heater prototype, we do not believe heat pump water heaters can be used as direct replacements for electric water heaters in many applications. There are many replacement water heater applications where present electric resistance water heaters are installed in small spaces, in attics and under counters. An example of such small spaces are the approximately 27% (10 million) of all electric water heaters installed in residences smaller than 1,000 ft^2 (average size: approximately 760 ft^2). In many of these installations, space restrictions would make it impossible to simply replace the existing electric resistance water heater with any of the existing heat pump water heater designs sold today. The DOE ''drop-in'' water heater is a candidate for some of these applications, but its current design does not address the problems of small spaces or small sizes.

Even the small (4,000–6,000 Btu/h) heat pump unit for the DOE ''drop-in'' water heater mounted on top of a tank will add approximately 8–12 inches on top of the tank for compressor, evaporator coils, and evaporator fan. Assuming no change in tank size from the electric resistance model, the extra height of the heat pump design will present installation problems where the existing water heater enclosure is height limited, such as many existing lowboy water heater installations.

GAMA reported that electric lowboy shipments account for about 18 percent of residential electric water heater shipments. (GAMA, No. 91 at 1). DOE appreciates the electric lowboy shipment information from GAMA.

About 18% of electric water heater sales are lowboy models. An integral heat pump water heater would not fit into these locations. Perhaps 50% of the lowboy sales would require an add-on heat pump unit. (The other 50% are for new construction.) Additionally, over one million standard sized electric water heaters per year are installed in residences of 1,000 ft^2 or less. Perhaps as many as half of these installations would also require an add-on heat pump unit. The lowboy and small residence replacements could equal 850,000 add-on heat pump water heaters per year. These add-on heat pump units require a space with at least 100 cubic feet per minute of warm air and wiring and plumbing connections (probably through one or more walls) for water pipes and a condensate drain. We would characterize this installation as ''difficult.'' Without an extensive survey, we are unable to determine how many of these difficult installations would be feasible, although costly, and how many would result in loss of product utility as discussed later in this section.

We have determined that almost a million households could be affected each year. Therefore, DOE eliminated heat pump water heaters as a design option from further consideration because of problems concerning practicability to install on the scale necessary to serve the relevant market at the time of the effective date of the standard.

Practicability to Service. We are also aware of the thousands of comments from interested consumers about heat pump water heaters in our 1994 NOPR. These comments cited lack of a good service infrastructure, noise, and reliability, among other factors. We have more recent comments from Northeast Utilities (NU) that significant (10%) reliability problems are still evident in some heat pump water heater designs. (NU, No. 4 at 1).

Two hundred sixteen comments to the 1994 rulemaking process (docket EE–RM–90–201) claimed that ''the infrastructure to service heat pump water heaters is not capable of handling a large quantity of heat pump water heater units.'' The issues faced in service and maintenance of heat pump water heaters have not changed since 1994. The present installation and service infrastructure for electric resistance water heaters consists, for the most part, of plumbers.

Heat pump water heaters are more complex in design and based on fundamentally different technology from electric resistance water heater designs. Because of this, they require a broader range of skills to service the units. Plumbers generally do not have training or background in repair of appliances like a failing heat pump water heater. Generally, this type of repair work is done by small appliance repair personnel who repair refrigerators, freezers, room air conditioners, and other ''white'' goods (e.g., washing machines). According to the Bureau of Labor and Statistics, of the approximately 71,000 home appliance repair workers in the U.S., two out of three work directly for department stores or household appliance stores. (1998–1999 Occupational Outlook handbook, U.S. Dept. of Commerce, BLS) These stores represent a small fraction of water heater sales but might be potential sales and service outlets for heat pump water heaters.

Presently, no mass-market servicing infrastructure for heat pump water heaters exists. While the air conditioning industry could provide servicing capabilities, only one company has any relationship with major water heater manufacturers or with plumbers who install water heaters. There is no precedent in the history of the U.S. major appliance industries to suggest that a new service and repair infrastructure could develop, on the scale of several million units per year, in a roughly three-year time frame.

Therefore, DOE eliminated heat pump water heaters as a design option from further consideration because of problems concerning practicability to service on the scale necessary to serve the relevant market at the time of the effective date of the standard.

Product Utility. Heat pumps need a certain amount of space for proper operation because a heat pump heats water by removing heat from the household air. Many heat pump water heaters currently available require a volume of at least 1,000 ft^3 of heated air to provide adequate heat exchange and minimize overcooling of the space, which can impact performance. Approximately 14% of all households are smaller than 1000 ft^2 and presently use electric water heaters. The volume of heated air required for a heat pump is equal to 12% of the floor space of a 1,000 ft^2 home. Therefore, in smaller residences, current or prototype heat pump units would have to be located in the living space, or have vigorous (100 cubic feet per minute) air exchange within the living space. Such a location can lead to significant homeowner dissatisfaction due to loss of space occupied by the unit and related piping, as well as the potential for noise of the fan and compressor. This is particularly a concern in small, slab-on-grade housing, mobile/manufactured homes or apartments.

If there is no space to incorporate both the water tank and the refrigeration subsystem in the same location, a reduced tank size may have to be installed. This could cause a 20% to 25 % loss of tank volume on a standard 50 gallon water heater. Any substantial reduction in the tank size to accommodate the heat pump would reduce the first hour rating, since first hour rating depends on tank size and reheat capacity. The first hour rating is, ''an estimate of the maximum volume of ''hot'' water that a storage-type water heater can supply within an hour that begins with the water heater fully heated.'' (10 CFR 430, subpart B, appendix E). We interpret losses of first hour rating as a loss of product utility.

DOE believes heat pump water heaters should be eliminated from further consideration because there would be a loss of utility to a significant portion of the population (10 million households). Therefore, because of this significant adverse impact to significant subgroups of consumers, the Department has eliminated heat pump water heaters as a design option from further consideration.

In summary, DOE has eliminated residential heat pump water heaters as a design option for this rulemaking because they fail to meet two of the three screening criteria listed earlier—namely, they are impracticable to manufacture, install, and service and have adverse impacts on product utility. There is no foreseeable means for the technology to advance enough in the short term to allow heat pump water heaters to fill market needs and to continue to provide a reasonable level of consumer utility.

As a result of its screening analysis, DOE has determined that heat pump water heaters are not economically justified. This conclusion is based on the following factors: (1) a capital investment that is 2.3 times the current industry net present value; (2) adverse utility impacts on about 10 million households living in homes with less than 1,000 square feet; and (3) adverse impacts on low income and seniors-only households due to a price increase about 3 times the expected 2003 baseline price for electric water heaters.

b. Gas Condensing Water Heaters

Although several manufacturers offer gas condensing water heaters, these are only in commercial sizes. Results from a GRI sponsored field test showed no serious reliability or durability problems and confirmed technical feasibility. (ASHRAE Transactions, 1987, 93(2) p. 1485–1500.) However, DOE is not aware of any prototypes or commercially available residential condensing gas-fired water heaters. Therefore, we have eliminated this design option based on a lack of technological feasibility. We discuss the details in Chapter 4.2.2 of the TSD.

c. Other Water Heater Design Options

DOE has eliminated air-atomized oil burners, power vents, and increased heat exchanger surface areas. Based on comments, DOE eliminated air-atomized burners on the basis that they are not technologically feasible because the prototype has not been applied to water heaters. We eliminated power vents because they require special venting systems that cannot be installed in applications such as existing multifamily homes and some existing town homes and condos. However, the Department is aware of a new, low volume fan that may allow power venting of an oil-fired water heater unit with conventional negative draft vent systems. Test results of this technology are not available. We eliminated the increased heat exchanger surface areas (for gas-fired water heaters) because improved flue baffles can provide the same efficiency improvement and are preferred by manufacturers.

After considering the above, the following are the design options considered for the rulemaking (see Table 1).

TABLE 1.—DESIGN OPTIONS USED IN THE ANALYSIS

Design options—description	Gas	Electric	Oil
Heat traps	X	X	X
Plastic tank	(1) X	X	
Increased jacket insulation	X	X	X
Insulating the tank bottom (electric only)	....	X	
Improved flue baffle/forced draft	X	....	X
Increased heat exchanger surface area	X	....	X
Flue damper (electro-mechanical)	X	....	
Side-arm heater	X	....	
Electronic (or interrupted) ignition	X	....	X

[1] used only in conjunction with the side-arm heater option.

D. Engineering Analysis of Design Options

The engineering analysis determines the maximum technologically feasible energy efficiency level, calculates unit energy savings and payback, and estimates the retail price for each design option and combination of design options. It analyzes the design options identified as a result of the screening analysis. This section discusses DOE's analytical tools and the critical assumptions DOE used in the water heater engineering analyses. We also discuss two initiatives by other Federal agencies that impact the rulemaking analyses.

1. Other Federal Agencies' Initiatives

Two actions by other Federal agencies outside of the DOE efficiency standards process will affect our engineering analyses. First, the U.S. Environmental Protection Agency (EPA) is requiring a phase out of the blowing agent currently used by the water heater industry for foam insulation (HCFC–141b). Second, manufacturers have reached a voluntary agreement with the Consumer Product Safety Commission (CPSC), to produce gas-fired water heaters resistant to ignition of flammable vapors. The first will affect the efficiency of water heaters, and the second will increase the price of gas-fired water heaters.

Most residential water heaters are insulated with polyurethane foam in the cavity between the tank and the jacket. Currently, water heater manufacturers use a hydrochlorofluorocarbon, HCFC–141b, as a blowing agent for this insulation. HCFC–141b is an ozone-depleting blowing agent and, as a result of the Montreal Protocol, the EPA has scheduled the phase-out of this blowing agent by January 1, 2003. Water heater manufacturers must use another blowing agent after that time.

A number of alternative blowing agents are available. The industry is considering HFC–245fa, HFC–356mfc, HFC–134b, cyclopentane and water blown foam. DOE decided to analyze two blowing agents—water-based and HFC–245fa. We based our decision on a number of criteria, including zero ozone depletion potential, low global warming potential, availability by 2003, and price. In our preliminary analysis, presented at the July 1999 Workshop, we only analyzed one of the alternatives—water blown insulation. Some stakeholders raised concerns about our failure to include HFC–245fa blown insulation in our preliminary analysis. Therefore, we added HFC–245fa blown insulation to our analysis.

We used HFC–245fa and water blown foam in our analysis. For cost information, Honeywell, the licensee to manufacture HFC–245fa in the U.S., provided estimates of HFC–245fa costs. For efficiency data, we used published laboratory measurements of physical parameters. In order to keep the baseline efficiency (those with HCFC–141b insulation) and the energy use characteristics of water heaters with HFC–245fa insulation the same, we modeled it with appropriately thicker insulation. We also increased the amount and cost of steel used for the water heater jacket in addition to the extra volume and cost of insulation. The analysis and test results using HFC–245fa and water blown foam to evaluate design options can be found in Chapter 3.4.1 of the TSD.

Many comments addressed the potential of other alternatives. GRI claimed other types of insulation may be preferable to HFC–245fa blown insulation. (GRI, No. 48 at 2). The Oregon Office of Energy (OOE) requested that DOE provide a succinct and complete summary of the alternative insulations and why they were not considered in the analysis. (OOE, No. 96 at 5).

In addition to the water/carbon dioxide (CO_2) and HFC–245fa blowing agents, there are cyclopentane, HFC–134a, and HFC–365mfc. All of these have zero ozone depletion potential and thus will meet the Montreal Protocol's requirements. Cyclopentane, widely used in Europe, is relatively inexpensive and highly flammable; U.S. manufacturers have been cautious about its use. HFC–134a is currently available, but its thermal resistance is lower than HFC–245fa. HFC–365mfc may be a good potential alternative blowing agent, but it also has a lower thermal resistance than HFC–245fa and its price is not available. Our decision to analyze both HFC–245fa and water/CO_2 blowing agents allowed us to cover the range of performance and costs of the suggested alternative blowing agents. We have more detailed information about alternative blowing agents in Chapter 3.4 of the TSD.

Although we have analyzed HFC–245fa as a blowing agent, there is continuing concern about its availability. Representatives from Honeywell, the licensee to manufacture the material in the U.S., stated at the July 1999 workshop that it would have a commercial size plant ready to produce HFC–245fa by mid-2002. (July 22, 1999 Water Heater Workshop Transcript, pg. 105). We received comments from several manufacturers, GAMA, an individual, and an insulation supplier about the availability of HFC–245fa and Honeywell's capacity to supply the market. GAMA and manufacturers are concerned that Honeywell is the only source for HFC–245fa. They are also concerned that manufacturers need samples of HFC–245fa soon as it will take about six to nine months to replace existing low pressure foaming equipment with high pressure equipment and shrinkage tests will take 250 days. (Stepan, No. 86 at 1; Bradford White, No. 89 at 2; Vaughn, No. 56 at 1; Rheem, No. 95 at 1; GAMA, No. 91 at 2; and Energy Market and Policy Analysis, Inc. (EMPA), No. 88 at 9).

Several comments suggested ways to deal with issues concerning the availability of HFC–245fa. The American Council for an Energy-Efficient Economy (ACEEE) suggested HCFC–141b could be stockpiled, the EPA could be petitioned to extend the phase out of HCFC–141b, or DOE could make the new standard conditional on the availability of HFC–245fa. (ACEEE, No. 93 at 7). SC and EEI suggested DOE delay implementation of the new water heater standard if HFC–245fa based insulation materials are not available. (SC, No. 42 at 2 and EEI, No. 39 at 2).

DOE is concerned about the relatively short time the manufacturers have to incorporate a new blowing agent into production and to perform the necessary tests to measure results using the new blowing agent. Since the choice of insulation blowing agent has a significant impact on energy savings and water heater cost, we request stakeholder comment on the cost and availability of HFC–245fa and water blown foam, and other alternative blowing agents. We also invite comments on approaches that would enhance the transition to a new blowing agent for manufacturers, including, but not limited to, the timing needed for the transition of HFC–245fa, water blown foam, or any other alternative blowing agent manufacturers suggest would be appropriate to use in implementing a new standard. Manufacturers are requested to submit supporting data for alternative blowing agents.

On September 13, 1999, we received updated information indicating that Honeywell had received EPA approval for production of HFC–245fa. Honeywell has since announced it would start building a commercial plant for producing HFC–245fa in Geismar, Louisiana. Based on Honeywell's announcement, we have decided to base our decision on insulation blown with HFC–245fa because such insulation is 42% more effective in reducing thermal losses than water blown insulation. Therefore, since our proposed standard uses HFC–245fa, this notice addresses the results based on HFC–245fa blown insulation. However, the Department has completed an identical analysis using water blown foam in order to anticipate the unlikely event that HFC–245fa does not become available.

The other action affecting this rulemaking is a CPSC initiative to make gas-fired water heaters resistant to ignition of flammable vapors. Most current designs for gas-fired water heaters rely on a standing pilot to ignite the main burner. If flammable vapors are in the air near a water heater, there is the possibility of unintended ignition. This is a potential safety problem because water heaters are often installed in garages and basements, where flammable liquids such as gasoline or paint thinners may be used. The CPSC staff recommended publication of an advance notice of proposed rulemaking for the development of a test procedure that would determine whether a particular gas-fired water heater design would ignite flammable vapors. However, before the notice was published, the water heater manufacturers agreed to voluntarily develop a test procedure and new gas burner designs.

The CPSC worked with GRI and the water heater industry to develop a test procedure for gas-fired water heater designs that will resist ignition of flammable vapors. The American National Standards Institute (ANSI) Z21 Committee approved this test procedure in May 1999, but final approval by the full ANSI committee is still pending. Gas-fired water heaters designed to be resistant to the ignition of flammable vapors are now on the market. Manufacturers have agreed to begin marketing gas-fired water heaters resistant to ignition of flammable vapors by April 2001. DOE will consider those additional economic impacts on manufacturers of the transition to designs resistant to flammable vapors. The voluntary agreement between manufacturers and the CPSC will be implemented by April 1, 2001, which will be close to the effective date of this rule.

The impact of this initiative on the water heater rulemaking analyses is an increase in manufacturing cost. Based on discussions with the Water Heater Industry Joint Research and Development Consortium, DOE decided to add an extra $35 per unit of manufacturer cost for designs resistant to ignition of flammable vapors. In this analysis, the $35 is applied to the manufacturing cost of all design options for gas-fired water heaters, including the baseline design. EEI stated that the cost of $35 may be very conservative. (EEI, No. 39 at 5). We believe until flammable vapor ignition resistant designs are widely available in the market, and a market price is established, a manufacturer cost of $35 is reasonable. We discussed this during the manufacturing interviews, and several agreed with this cost estimate. Furthermore, the design does not require electricity for the water heater or modifications of the venting system. DOE also anticipates no changes in efficiency from flammable vapor ignition-resistant water heater designs. DOE will monitor this situation to verify these assumptions or to update the analysis, as designs meeting the ANSI standard become available.

2. Maximum Technologically Feasible Levels

Amendments to a standard are required to achieve the maximum improvement in energy efficiency that is technologically feasible and economically justified. Section 325(o)(2)(A), 42 U.S.C. 6295(o)(2)(A). Furthermore, Section 325(p)(2) requires that the Secretary determine the maximum technologically feasible level (max tech) for each type (or class) of covered product and then, if the proposed standard is not designed to achieve the max tech levels, state the reasons that it will not meet those levels.

The Secretary has determined heat pump water heaters for electric, and gas condensing water heaters, are the max tech design options. This means the max tech level for electric is 1.7 EF and for gas is 0.91 EF. The max tech level for oil is 0.61 EF. However, as a result of our screening analysis, the max tech levels for electric and gas-fired water heaters have been eliminated. Therefore, the proposed standard for both electric and gas-fired water heaters will not achieve the max tech levels. The reasons for this decision are described in our discussion on screening, and in Chapter 4.2.2 of the TSD. Accordingly, the Department has satisfied the requirements of Section 325(p)(2), 42 U.S.C. 6295(p)(2).

Therefore, we combined the design option technologies that were not screened out into successively more efficient design options until we reached the highest efficiency levels for each product class. We combined design options by using our payback analysis. We define payback as the time required to recover the cost of efficiency improvements through energy savings. We started with the design option with the shortest payback and continued to add design options with the next shortest payback at each higher efficiency level. See Table 3 for design option combinations. The highest efficiency levels for this rulemaking are approximately 0.91 EF for 50-gallon electric water heaters, 0.71 EF for 40-gallon gas-fired water heaters, and 0.61 EF for 32-gallon oil-fired water heaters.

3. Methodology

Table 2 summarizes the information we used in the engineering analysis and the assumptions we made. We briefly discuss many of the assumptions in this section. For complete details about the engineering analysis, please see Chapter 8 in the TSD.

TABLE 2.—KEY ELEMENTS USED IN THE ENGINEERING ANALYSIS

Description	Elements
Product classes	Electric, gas (includes LPG) & oil.
Analysis approach	Design options.
Designs analyzed	Heat traps, thicker insulation, tank bottom insulation on electric, 78% & 80% RE on gas, 78% & 82% RE on oil, plastic tank on electric, side-arm heater, & IID on gas, interrupted ignition on oil.
Simulation models	WATSIM for electric, TANK for gas, WHAM for oil.
Basis for energy factor	DOE water heater test procedure, 64.3 gpd.
Baseline energy factor	Electric, 50 gallon =.86, gas, 40 gallon =.54, oil, 32 gallon =.53.
Cost data	Provided by GAMA and consultants and the Water Heater Consortium ($35, resistance to ignition of flammable vapors).
Price data	Water heater price database.
Insulation blowing agent	HFC–245fa (Water blown insulation analyzed in TSD).
Insulation cost	Existing—HCFC–141b blown—$1/lb from Honeywell. New—HFC–245fa blown—$1.32/lb, from Honeywell.
Insulation thicknesses	2 inch, 2.5 inch & 3 inch.
Warranty on baseline	6 years or less.
Markup	Average baseline price divided by average manufacturer baseline cost.
Installation costs	$160 for door jamb removal & replacement on 27% of all designs with 3-inch insulation. $114 for Type-B vent connectors in 25% of homes in northern states with 78% RE on gas-fired. $433 for chimney relining and Type-B vent connectors in 25% of homes in northern states with 80% RE on gas-fired.
Maintenance costs	None on electric, $14.73/yr for the side-arm heater for gas-fired and a $97.14 yearly maintenance contract for oil-fired.

a. Energy Savings Potential

Having determined the highest energy efficiency levels for each product in this rulemaking, the Department then estimates the energy savings potential of individual design options or combinations of design options. Table 3 shows the design option combinations for each fuel type at incremental levels of efficiency. (These do not represent trial standard levels.) We use simulation model calculations and manufacturer data to determine the efficiency levels corresponding to various design option combinations.

TABLE 3.—DESIGN OPTION COMBINATIONS

Design option level	Design option for electric water heaters	Design options for gas-fired water heaters	Design options for oil-fired water heaters
1	Heat traps	Heat traps	Heat traps.
2	Heat traps + tank bottom insulation.	Heat traps + flue baffles (78% RE)	Heat traps + 2 inch insulation.
3	Heat traps + tank bottom insulation + 2 inch insulation.	Heat traps + flue baffles (78% RE) + 2 inch Insulation.	Heat traps + 2.5 inch insulation.
4	Heat traps + tank bottom insulation + 2.5 inch insulation.	Heat traps + flue baffles (78% RE) + 2.5 inch insulation.	Heat traps + 3 inch insulation.
5	Heat traps + 2.5 inch insulation + plastic tank.	Heat traps + flue baffles (80% RE) + 2 inch insulation.	Heat traps + 3 inch insulation + flue baffles (78% RE).
6	Heat traps + 3 inch insulation + plastic tank.	Heat traps + flue baffles (80% RE) + 2.5 inch insulation.	Heat traps + 3 inch insulation + flue baffles (78% RE) + interrupted ignition.
7		Heat traps + flue baffles (80% RE) + 3 inch insulation.	Heat traps + 3 inch insulation + interrupted ignition + increased heat exchanger area (82% RE).
8		Heat traps + flue baffles (80% RE) + 3 inch insulation + side arm + electronic ignition + plastic tank.	

2003 Baseline Model. As discussed earlier, the Department defines a baseline unit in order to analyze options which increase energy efficiency over the baseline. Because DOE expects new energy-efficiency standards to take effect near the phase-out date (2003) of HCFC–141b, we had to create a baseline model for this analysis which uses foam insulation blown with an acceptable alternative blowing agent. After considering all possible insulation choices, the Department determined that the most likely alternatives to replace HCFC–141b appears to be water and HFC–245fa. Consequently, we performed a complete analysis using these two different blowing agents. After weighing the comparative benefits and costs of HFC–245fa and water blown foam and then taking into account Honeywell's announcement on the availability of HFC–245fa, we ultimately selected HFC–245fa as the insulation for our proposed trial standard levels.

To model the baseline electric water heater under existing efficiency standards with the alternative blowing agents, we increased the foam insulation thickness to 1.55 inches for HFC–245fa. To model the gas-fired water heater baseline for the alternative blowing agents, we increased the foam insulation thickness to 1.0 inch for HFC–245fa. To model the oil-fired water heater baseline for the alternative blowing agents, we assumed a foam insulation thickness of 1.01 inches for HFC–245fa. We made similar calculations for water blown foam so we could perform a comparative analysis throughout the TSD.

Computer Simulation Models. To analyze the energy efficiency of water heaters with various combinations of design options, DOE used computer simulation models for electric (WATSIM) and gas-fired (TANK) water heaters, and a spreadsheet model (WHAM) for oil-fired water heaters. AGA commented that it preferred modeling results because modeling allows the use of consistent assumptions across design options. (AGA, No. 49 at 1).

WATSIM Model for Electric Storage Water Heaters. WATSIM is a detailed electric water heater simulation program developed by Electric Power Research Institute (EPRI). (Report #TR–101702, 10/92). WATSIM contains two simulation algorithms: one for the detailed simulation of water heater tanks and the other for controlling water draw profiles. The output of WATSIM provides detailed temperature profiles of the water inside the water heater tank. We use these temperature profiles to determine the EF and other parameters of the water heater using the test DOE procedure calculations.

Our analysis began with a simulation of a baseline model (i.e., one that is currently marketed that achieves a minimum allowable efficiency of 0.86 EF). When simulating the typical existing electric water heater, WATSIM was able to achieve the minimum allowable efficiency of 0.86 EF by simulating a jacket thickness of 1.5 inches of HCFC–141b foam insulation. OOE, The Northwest Energy Efficiency Alliance (NEEA), The Northwest Power Planning Council (NWPPC), and ACEEE, did not support DOE's use of 1.5 inches of foam on electric water heaters to adjust the model results of EF 0.83 to reach the minimum EF of 0.86. (OOE, No. 44 at 3; NEEA, No. 53 at 2; NWPPC, No. 43 at 1; and ACEEE, No. 52 at 2). The commenters did not support this because the GAMA directory listed one model with 1 inch of insulation. Manufacturers indicated to DOE that 1.5 inches of foam insulation on electric water heaters is the norm to meet the minimum efficiency of 0.86 EF for a 50-gallon electric water heater. Therefore DOE chose to use 1.5 inches in its simulation.

Complete verification of the WATSIM program is not currently available to the public. The WATSIM user's manual states the model "has been vigorously verified for use in tank and system design, equipment sizing, and individual or diversified demand analyses, as well as for energy consumption analysis." (EPRI, TR–101702, 10/92). The Department validated the WATSIM simulations by comparing them to NIST measurements. NIST tested four mid-efficiency 50-gallon commercially available electric water heaters and reported an average 0.89 EF. (Fanney, 1999 ASHRAE Summer Meeting). The Department compared the NIST EFs with WATSIM simulations of identical water heater models. The results agree within 0.01

EF. Subsequently, NIST tested five high efficiency electric water heaters and we validated the WATSIM model to the highest of the five test results, 0.91 EF. The WATSIM modeled results were within 0.002 EF of the NIST test results. These validations are in Chapter 8.2.4.1 of the TSD. Therefore, we believe WATSIM is accurate over the range of EFs considered in this rulemaking.

Based on our selected design options, the WATSIM model predicts a maximum of 0.91 EF for electric water heaters. Stakeholders raised concerns at the November 1998 Workshop that the GAMA directory lists 0.93 EF and higher EFs for electric water heaters. NEEA, NWPPC, VP, OOE, the National Resources Defense Council (NRDC), and ACEEE claim DOE should investigate and reconcile the differences between the EFs predicted by computer models and those listed in the GAMA directory. (NEEA, No. 53 at 1; NWPPC, No. 43 at 1; VP, No. 45 at 1; OOE, No. 44 at 1; NRDC, No. 46 at 1; and ACEEE, No. 52 at 1). ACEEE stated the difference between computer simulation and directory listings is about 0.03 efficiency points for electric water heaters. ACEEE stated DOE must explain what it intends to do to ensure that EF ratings are accurate. (ACEEE, No. 75 at 3). DOE is investigating the discrepancies in EF ratings between the GAMA directory and the WATSIM modeled results.

NIST measured one high efficiency electric water heater from each manufacturer and found an average 0.036 EF lower on test results than in the GAMA directory listing. DOE also received data from GAMA on its certification testing program for 1994 through 1998. We reviewed this data and found that for the 26 high efficiency electric water heaters measured, results averaged 0.02 EF lower than published EFs in the GAMA directory. The NIST and GAMA certification program test results were consistent with the WATSIM simulation program results. Therefore, DOE will base its analysis of electric water heater performance on WATSIM results.

Some stakeholders raised concerns about the test procedure. EEI and SC claimed there may be measurement problems when determining the electric water heater EF, since electric water heaters are close to their maximum potential thermodynamic efficiency levels. (EEI, No. 39 at 2 and SC, No. 42 at 2). Vaughn claimed the error factor in the test equipment is greater than the obtainable increase in energy efficiency. (Vaughn, No. 56 at 1). VP recommended DOE determine and report the confidence level of EF results from the water heater test procedure to ensure that the difference between the existing efficiency standard and any proposed standard is within the accuracy of the test procedure. (VP, No. 45 at 2). EPRI claimed that routine EF testing performed at testing laboratories is only within 3 percent accuracy. (EPRI, No. 41 at 1). DOE investigated this problem with Intertek Testing Services (ITS), NIST, and the manufacturers. ITS claimed that its test repeatability is within 0.5%. NIST has demonstrated accuracy better than 1 percent. NIST and ITS recently measured the EF on the same model of two electric water heaters. The results agreed within 0.008 EF. Based on these responses, DOE does not believe there is a problem in accurately measuring performance results that will adversely affect any manufacturers' ability to certify compliance with the proposed energy efficiency standard for electric, gas-fired, or oil-fired water heaters.

TANK Model for Gas-Fired Storage Water Heaters. TANK is a detailed gas-fired storage water heater computer simulation program developed by Battelle for GRI, (GRI–93/0186). TANK calculates energy flows throughout a water heater including water draws, flue heat losses, jacket heat losses, fittings heat losses, and combustion chamber heat losses. Unlike WATSIM outputs, TANK outputs include the EF, RE, and UA from the DOE test procedure.

To validate the analytical models comprising the TANK program, Battelle conducted actual water heater testing and monitoring. Battelle performed a set of tests to investigate the impacts of different flue baffle designs, increased insulation thickness, and different pilot light input rates on EFs. Battelle compared test results to the TANK model results. Battelle then tested gas water heaters under the assumptions of the DOE test procedure to validate the analytical predictions of TANK. Battelle reported the results in terms of EF, RE, UA, and total standby loss. Overall, the difference between the experimental values (measured) and the predicted values (simulated by TANK) is less than 0.01 EF for all of the above parameters.

With the TANK simulation model for gas-fired water heaters, we consulted with Battelle to develop characteristics similar to the Battelle baseline model with a nominal insulation thickness of 1 inch. GAMA comments stated that the manufacturers use a 450 Btu/hr pilot light on gas water heaters. (GAMA, No. 51 at 1). DOE used this new heat input rate for pilot lights on gas-fired water heaters. See Chapter 8.2 of the TSD for details about the simulation models and the baseline characteristics.

WHAM Energy Calculation for Oil-Fired Storage Water Heaters. We used a simplified spread-sheet model (WHAM) for our engineering analysis of oil-fired water heaters. WHAM is based on the 24-hour simulated use test portion of the DOE test procedure. The model calculates energy consumption from a water heater's RE, UA, and rated input (P_{on}). (Lutz, J., et al, 1998, ACEEE Summer Study on Energy Efficiency in Buildings, pp. 1.171–1.183). The model assumes the water temperature remains at the set point temperature throughout the tank. We also assume RE and UA are constant.

To validate WHAM, we compared the results of the WHAM equation to results of the WATSIM and TANK simulation models of residential electric and gas-fired storage water heaters with excellent agreement. WHAM and WATSIM results are within 3% or less and WHAM and TANK results are within 5% for normal operating conditions, tank sizes and design options.

b. Comments on Design Options

Tank Bottom Insulation. One design option considered for electric water heaters is insulation under the bottom of the tank, referred to as tank bottom insulation. EPRI and Bradford White commented that they do not observe the efficiency improvement from insulating the tank bottom that WATSIM predicts. (EPRI, No. 70 at 2 and Bradford White, No. 89 at 3). Based on DOE's computer simulation results, and loss mechanisms NIST observed by infrared photography, DOE believes the improvement in efficiency is real. The infrared photography shows much warmer regions at the base of water heaters and around piping penetrations than any other tank surfaces. (Fanney, Zarr and Ketay-Paprocki, 1999 American Society for Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) Summer Meeting). We have also discussed this approach with a manufacturer who uses molded insulation under its tanks. This manufacturer believes water heater performance is improved but did not provide any test data to confirm the observation. Therefore, we will continue to use the WATSIM EF results in our analyses.

Insulation Effectiveness. Due to water heater tank geometry and the method of pouring liquid insulation into the jacket which then forms in place, the insulation effectiveness may not be consistent between the sides and top of the tank. Bradford White recommended DOE limit the foam cavities to 2.5 inches in electric, 1.5 inches in gas-fired, and 1 inch in oil-fired water heaters. Bradford White stated the insulation effectiveness of foam does not double for 2 inches or triple for 3 inches due to variations in cell structure as the foam rises vertically and spreads horizontally in the jacket cavity. (Bradford White, No. 89 at 3). To account for this, we derated the effectiveness of HFC–245fa blown insulation by about 10%. This allowed us to assume a uniform thickness and constant insulation effectiveness on the sides and top of the tank in the simulation models.

Insulation Thickness. With water heaters, the thickness of the insulation cavity helps determine the diameter and height for a given tank volume. This is an important consideration in water heater product utility since some water heaters are installed in tight spaces and reduction of tank volume could reduce the first hour rating. SC and EEI claimed water heaters can become too wide to fit through residential interior doors if the insulation is too thick, and therefore the thickness of the insulation should be limited. (SC, No. 42 at 2 and EEI, No. 39 at 7). GAMA stated DOE should not consider insulation thicknesses beyond 3 inches because replacement units must be able to fit through doorways. (GAMA, No. 33 at 3). DOE agrees with the GAMA recommendation and has limited insulation thicknesses to 3.0 inches or less.

We also have comments from GAMA, Connecticut Natural Gas (CNG) and New England Gas Association (NEGA) that thicker insulation will raise installation costs, cause installation of multiple smaller units, or inconvenience consumers with a smaller sized, lower capacity unit. (GAMA, No. 91 at 1; CNG, No. 85 at 2; and NEGA, No. 90 at 3). GAMA and Bradford White claimed a 2.5 inch insulation thickness will increase the diameter and height of electric water heaters and product utility will be impaired, particularly for 20–50 gallon lowboys and tabletop models. (GAMA, No. 71 at 4 and Bradford White, No. 74 at 2). We reviewed the application of these water heaters in households in multi-family buildings, mobile homes and manufactured housing, and we estimate only a small percentage of households may be affected (see Chapter 3.4.4 in the TSD). Furthermore, we believe a 6 kW heating element should eliminate any lost first hour rating in those situations where a smaller capacity tank is required.

Flue Baffles. The flue baffle, the twisted strip of metal inserted into the flue of a gas or oil-fired water heater, is the most commonly used method to improve heat transfer, thereby improving RE. RE is the percentage of energy transferred to the hot water compared to input energy. It takes into account the amount of energy lost through the flue and other parts of the water heater.

There are many design options available to increase RE. Because of the low cost, the Department has assumed in its analysis the flue baffle alone would be the most cost effective method for increasing RE up to 80%. GAMA stated recovery efficiencies higher than 78% cannot be attained by modifying the flue baffle only. (GAMA, No 71 at 3). ACEEE claimed there are other technologies that can be combined with flue baffles to achieve 80% RE in gas-fired water heaters. (ACEEE, No. 93 at 6). However, several manufacturers and consultants told DOE they could reach 80% RE by modifying flue baffles alone. For the July 1999 workshop, DOE assumed flue baffles could be modified to increase RE to 78% or 80% from the current baseline of 76%. We will analyze 78% and 80% RE based on modifying flue baffles as design options.

Bradford White claimed the flue baffle improvement to increase the recovery efficiency in oil products is possible, but only with a specific patented approach. (Bradford White, No. 74 at 3). DOE's analysis assumes several designs are possible, such as multi-flues, internally finned flues or a finned combustion chamber. We used the patented Bock Turboflue as a proxy to determine the performance of the increased heat exchanger area on oil-fired water heaters and reduced the performance to be conservative, since we were not confident a non-proprietary design would achieve the same level of performance. To estimate the costs of the increased heat exchanger area design, we examined other approaches for providing increased heat exchanger area that are not proprietary, and we have estimated retooling and materials costs based on the use of these other approaches. We used this design to complete the list of energy factors and costs for oil-fired water heaters since this is the maximum technologically feasible level for oil-fired water heaters.

Venting for Gas-fired Water Heaters. Most water heaters sold today are for the replacement market, where an existing vent system is in use. Improving the flue baffle can significantly increase the RE of a water heater, which in turn can reduce the temperature of the flue gases leaving the water heater. A reduction in temperature of the flue gases can increase the likelihood of condensation. Due to excessive moisture condensing from the flue gases, use of increased RE gas-fired water heaters with existing venting systems not designed for increased RE gas-fired water heaters can lead to excessive corrosion and failure of the vent system in certain climates. Studies conducted by GRI/Battelle have shown corrosion can occur when a vent wall becomes wet. While it is not uncommon for a vent to be wet immediately after the appliance starts, the appliance must heat the vent system and dry the walls before turning off. If the vent does not dry, corrosion may occur during a long period of wetness.

While we have discussed RE for water heaters, typically appliances are characterized for venting purposes by flue-loss efficiency. Flue-loss efficiency measures how much of the input heat does *not* go up the flue. The DOE test procedure for rating residential water heaters does not measure flue-loss efficiency; it measures RE instead. Therefore, RE was used in this analysis for measuring the impact on the flue vent system, but in order to estimate the impact of increasing the RE of a water heater, a relationship between RE and flue loss efficiency was needed. Flue loss efficiency is not always directly proportional to RE, but flue loss efficiency is typically 2–4% higher than RE.

RE of more than 80% is associated with flue-loss efficiencies exceeding 84%, resulting in excessive condensation within the vent system, which can lead to corrosion and a reduced vent system life. To ensure that condensation does not occur in the flue, only design options that increase RE to a maximum of 80% were selected for analysis. However, the Department recognizes that potential venting problems may occur in the 78–80% RE range and could require Type-B vent connectors and chimney relining. A Type-B vent connector is a double wall vent, with an aluminum inner wall and a galvanized steel outer wall. The special double wall construction keeps flue gases hot while inside the vent, providing a strong draft and minimizing condensation. Additionally, the aluminum inner wall is more corrosion resistant to condensation that may occur in the vent.

A number of comments supported a maximum RE level of 80% for an improved flue baffle design option. (ACEEE, No. 52 at 4; OOE, No. 64 at 1–4; ACEEE, No. 75 at 2; and OOE, No. 76 at 1). Additionally, ACEEE claimed, based on Table 3 in the GRI study (GRI–95/0198), the lowest flue-loss efficiency for homes with Type-B vent connectors and masonry chimneys is 84.5% and therefore no chimney relining should be needed for 80% RE. (ACEEE, No. 93 at

5). OOE claimed there are no inherent safety issues associated with REs of up to 80%. (OOE, No. 96 at 4).

Other comments raised concerns with a maximum level of 80% RE. LaClede Gas and GAMA stated DOE should not exceed a 76% RE in order to maintain an adequate margin of safety. (LaClede, No. 69 at 6 and GAMA, No. 71 at 3). CNG and NEGA claimed setting a standard level at 78% RE could lead to condensation and chimney degradation. (CNG, No. 85 at 1 and NEGA, No. 90 at 2). Bradford White said 78% is the maximum RE to avoid corrosion in the vent, but 77% is more realistic. (Bradford White, No. 74 at 2–3 and No. 89 at 2).

The Department is very concerned about public safety for venting of gas-fired water heaters. We appreciate the analysis by OOE and GRI. We also discussed venting concerns with state experts and chimney installers. As a result of these discussions and comments, as well as the GRI study (GRI–94/0193), we believe there are no technological barriers to using either 78% or 80% RE gas-fired water heaters in a replacement installation. Furthermore, in most replacement applications, vent systems and chimney reliners are available on the market to meet the venting requirements for water heaters with 78% or 80% RE. In new construction, installers can follow manufacturers recommendations so there are no problems with either a 78% or 80% RE.

Heat Traps. In its analysis for the July 1999 workshop, DOE used WATSIM and TANK default values for heat trap performance. Manufacturers claimed they could not achieve performance for heat traps when installed on actual water heaters. In its comments on heat traps, GAMA claimed DOE should use a 0.01 EF increase. (GAMA, No. 71 at 5). Bradford White provided heat trap data for oil-fired, gas-fired, and electric water heaters. (Bradford White, No. 74 at 1). ACEEE stated DOE should only change the heat trap effectiveness based on independent test data. (ACEEE, No. 93 at 8). DOE has averaged the GAMA and Bradford White heat trap data. This has not affected gas-fired water heaters' heat trap results, but it has reduced heat trap performance on electric water heaters by 0.005 EF. Based on the above, heat traps are estimated to result in improvements of 0.012 EF for electric, 0.09 EF for gas-fired, and 0.006 EF for oil-fired. These are the improvement values used in the analysis.

c. Manufacturing Costs

After determining the design option combinations, the Department also had to determine the cost to manufacturers and consumers to achieve increased efficiency. In the 1997 Rulemaking Framework Workshop, DOE and stakeholders discussed three methods used to generate the manufacturing costs for the engineering analysis. These methods included: (1) The design-option approach, reporting the incremental costs of adding design options to a baseline model; (2) the efficiency-level approach, reporting relative costs of achieving energy efficiency improvements; and (3) the cost-assessment approach, which requires a "bottom-up" manufacturing cost assessment based on a detailed bill of materials.

In written comments, GAMA recommended DOE use the design option approach in its economic analyses because "there are only a few identifiable discrete efficiency improvement measures possible for residential water heaters." (GAMA, No. 5 at 4). There were no other comments. At the water heater standards rulemaking workshop in June 1997, GAMA suggested it could collect and aggregate manufacturer costs on the design options of interest to DOE for this rulemaking. DOE accepted that offer and agreed to use the GAMA manufacturing cost data.

The use of a design-option approach provides useful information, such as the identification of potential technological paths manufacturers could use to achieve increased energy efficiency. It also allows the use of engineering models to simulate the energy consumption of different design configurations under various user profiles and applications. However, the Department recognizes that the manufacturer cost information derived in the design-option approach may not reflect the variability in design strategies and cost structures that can exist among manufacturers. Therefore, the Department derived additional manufacturing cost estimates from other approaches based on consultant's estimates, component manufacturers' prices, and occasionally from other interested parties. DOE had two retired water heater manufacturing engineers as consultants provide cost estimates and peer review our analysis results. We describe these costs in the TSD in Chapter 8.3.3 for electric, Chapter 8.4.3 for gas-fired and Chapter 8.5.3 for oil-fired water heaters.

GAMA provided most of the manufacturer costs with the exception of all oil-fired water heaters, the tank bottom insulation, and the plastic tank costs for electric and side-arm heater costs for gas-fired water heaters, which our consultants provided. GAMA based its cost estimates on the production of a 50-gallon electric or 40-gallon gas-fired water heater. GAMA separated the costs into variable (material, labor, transportation, overhead) and fixed (capital, product design) costs on a per-unit basis and provided a distribution of fixed, variable, and total manufacturing costs for several design options. We used GAMA's cost data and consultant data to determine the water heater manufacturer costs for all combinations of design options. OOE claimed GAMA's manufacturing costs for gas water heaters are too high. (OOE, No. 44 at 7). DOE could not get independent cost data directly from individual manufacturers, so we are unable to determine if the manufacturing costs for gas-fired water heaters are too high. We believe the data best represents the costs of all water heater manufacturers, as well as the incremental costs between design options.

GAMA based its existing baseline model cost estimates on an electric water heater with 1.5 inches of foamed jacket insulation using HCFC–141b as a blowing agent. The existing baseline is the starting point to construct the 2003 baseline cost, to determine markup, to develop incremental costs for heat traps and to build up incremental costs for a unit thickness of new insulation. For gas-fired water heaters, GAMA based its existing baseline model cost estimates on 1 inch of foamed jacket insulation using HCFC–141b as a blowing agent. To develop costs for thicker insulation, we estimated the material costs for the additional foam and blowing agent as well as the cost for additional sheet metal. We used Honeywell's estimate of $4 per pound for the material costs of the HFC–245fa blowing agent and Honeywell's estimate of 15% blowing agent in a standard insulation mixture. Since the blowing agent is only 15% of the final foam insulation, total insulation cost is $1.32 per pound for HFC–245fa compared to $1 per pound for HCFC–141b. We also assumed a value of $35 additional incremental manufacturing cost ($15 variable costs and $20 fixed cost) for designs to resist flammable vapor ignition in gas-fired water heaters. We discuss the cost assumptions for each design option below.

Heat Traps. GAMA provided manufacturer costs for electric and gas water heaters with heat traps. GAMA did not provide costs for the heat trap component. Vaughn stated the costs for heat traps should be the same for gas and electric water heaters. (Vaughn, No. 56 at 2). Vaughn is correct. Based on component costs from the heat trap manufacturer, we know heat trap costs are the same for gas and electric. However, we did not use the component costs because we needed to include labor, overhead, and other costs. Therefore, we continue to use the combined water heater plus heat trap costs.

Increased Jacket Insulation. GAMA provided variable and fixed cost data for jacket insulation increases based on HCFC–141b blown insulation from a baseline level of 1.5 inches on electric and 1 inch on gas-fired water heaters to a thickness of 2 inches only. Since HCFC–141b will be phased out in 2003, we had to develop costs for alternative insulation. Our consultant developed the cost of the 2003 baseline by adding incremental costs for HFC–245fa and sheet metal to the HCFC–141b baseline provided by GAMA. Our consultant used the same approach, adding the incremental costs for HFC–245fa and sheet metal to the GAMA data, for the 2 inch insulation thickness. Then, our consultant developed cost ratios from the incremental cost differences for 2.5 and 3 inch insulation thicknesses for the HFC–245fa blowing agent. We multiplied GAMA's incremental costs for 2 inches of insulation by these ratios to generate cost data in 2.5 inches and 3 inches of insulation. For cost information see Chapter 6.4 in the TSD.

Increased insulation creates a larger water heater than those typically installed today. Many replacement installations require the water heater to match the dimensions of the one it is replacing. One approach that addresses this issue was suggested in comments and discussed at the July 23, 1999 workshop, is to reduce the inner tank diameter slightly. Manufacturing a smaller inner tank diameter would require retooling for many manufacturers. Bradford White claimed retooling for different diameters of tanks cost $100,000 for each diameter. (Bradford White, No. 89 at 2). We agree with Bradford White on the retooling costs. From discussions with GAMA, we determined that the GAMA data accounts for any retooling cost associated with the trial standard levels, including any potential design changes to the inner tank diameter.

Insulating the Tank Bottom. ACEEE claimed GAMA's $40 cost for bottom insulation on electric water heaters is excessive. (ACEEE, No. 52 at 6). Based on discussions with manufacturers who use similar techniques, and our consultants' estimates, we determined the cost to be between $2 and $4. After the July 1999 workshop, GAMA and Bradford White claimed DOE should increase the $2–4 cost for tank bottom insulation because it has to be molded. (GAMA, No. 71 at 5 and Bradford White, No. 74 at 2). Based on our consultant's analysis and discussions with manufacturers who use tank bottom insulation, we believe the $2–4 cost is reasonable, so we did not change these costs after the July 1999 workshop. See Chapter 6.4 of the TSD for more details.

Plastic Tank. Our consultant provided the manufacturer costs for a plastic tank electric water heater design. See Chapter 6.4 of the TSD. Although GAMA did not provide cost information, GAMA believed the cost of the plastic tank option has been significantly underestimated. (GAMA, No. 51 at 3). Since GAMA did not provide any data to substantiate its statement, DOE has not changed its cost estimate.

Improved Flue Baffle. GAMA provided manufacturer costs for the improved flue baffle design. Originally, the costs were based on a flue baffle design that increased the RE to 78.5%. After the November 1998 workshop, we decided to use flue baffles that achieve 78% and 80% RE because we believed 80% RE was feasible although it entailed more risk of venting system condensation. Our consultant estimated that the manufacturing costs for tooling a flue baffle to achieve a 78% or 80% RE are identical. There is no change in material cost for a flue baffle achieving 78% or 80% RE.

OOE claimed as long as a conventional furnace shares the flue with a water heater, there should be no need for relining the flue regardless of the water heater efficiency. ACEEE estimated 1% of homes will need Type-B vent connectors and 17% will need flue relining. (ACEEE, No. 93 at 4–5). NEGA stated many New England consumers would have to install flue liners and Type-B vents at a cost of $800 if higher flue-loss efficiency gas-fired water heaters are mandated. (NEGA, No. 90 at 3). DOE estimates that at 78% RE, about 10% of the households with gas-fired water heaters in homes with over 5,000 heating degree days need Type-B vent connectors; at 80% RE, about 25% of these homes need Type-B vent connectors and chimney relining. DOE based its estimates on GRI data (GRI 91/0298) modified for: gas-fired water heaters in new homes (since 1994) that use different venting systems; and the current National Fuel Gas Code (NFGC), which requires replacement furnaces with higher efficiencies to have better vents in existing installations. Since 1992, the DOE furnace energy efficiency standards placed gas furnaces in a new category of the NFGC and consequently requires better vent systems in new construction. DOE also determined that Type-B vent connectors and chimney relining, which might be needed in the New England states, cost an average of $508.

OOE claimed the GRI report shows water heaters located in a conditioned space have no special venting requirements and no requirement or cost for a Type-B vent connector. OOE claimed Type-B connectors should be used when water heaters are installed in unheated spaces. Therefore, there is no additional vent connector or flue relining cost associated with higher water heater efficiencies. (OOE, No. 44 at 5). OOE claimed there is no need for Type-B venting or relining of chimneys for a water heater with an 80% RE that would not also be required for one with a 76% RE. (OOE, No. 96 at 2). In order to be conservative and provide a margin of safety, DOE assumed up to 25% of homes in cold climates with gas-fired water heaters may need vent connectors or relining of chimneys for 80% RE. We included this assumption in both the LCC and NPV analyses. It effectively increases consumer costs.

Electro-Mechanical Flue Damper. GAMA provided manufacturer costs to include an electro-mechanical flue damper and electronic ignition with a gas-fired water heater. We used these costs in the analysis.

Side-Arm Heater and Plastic Tank. Our consultant provided manufacturer costs for the side-arm heater for a gas-fired water heater design because GAMA received a response from only one manufacturer and could not provide this information for confidential reasons. We considered costs for six types of side-arm heater designs: 76%, 78%, and 80% RE designs using a metal tank and electronic ignition, and 76%, 78%, and 80% RE designs using a plastic tank and electronic ignition. Based on our analysis, we determined the cost increase of the 78% or 80% RE designs were the same and were equal to the cost of the improved flue baffle design option. This means heat exchanger costs for side-arm heaters with 78% or 80% RE are equal. GAMA disagreed with DOE's cost estimate for the side-arm heater design option; however it did not provide any specific information. (GAMA, No. 51 at 3). Therefore, we are using our cost estimate, absent any other information. Furthermore, GAMA did not comment on this issue at our July 1999 workshop.

Oil-Fired Water Heaters. GAMA did not receive information from enough manufacturers to allow it to aggregate cost data for oil-fired water heaters. Therefore, DOE relied completely on its consultants' cost data for each design option considered for the oil-fired water heater analysis. See Chapter 6.4.3 of the TSD for details.

Bradford White suggested DOE only increase the performance of oil-fired water heaters by applying heat traps because the burner is usually not supplied with the tank and would therefore need a conversion kit. Bradford White also stated DOE's cost estimates for a conversion kit are too low. (Bradford White, No. 89 at 3). DOE considered two trial standard levels using only heat traps for oil-fired water heaters. However, the oil burner manufacturer, who supplies most of the water heater oil burners, provided our cost estimates for the conversion kit.

d. Installation Costs

The installation cost is the cost to the consumer of installing the water heater and is separate from the retail price. The cost of installation covers all labor and material costs associated with the simple replacement of an existing water heater. Delivery, removal, and permit fees are also included.

We established the installation costs of baseline 50-gallon electric, 40-gallon gas-fired, and 32-gallon oil-fired water heaters from the same sources as the retail price data. DOE assumed only the 3-inch insulation thickness would increase installation costs for gas-fired and electric water heaters installed within a conditioned space based on stakeholder comments and discussions at the manufacturer interviews. Four design options increased the cost of installing a gas-fired water heater. They are the improved flue baffle, electronic ignition, electro-mechanical flue damper, and side-arm heater.

In comments, ACEEE and VP claimed installation costs differ in new construction and in existing homes. (ACEEE, No. 23 at 2 and No. 52 at 6; and VP, No. 45 at 2). GAMA suggested DOE's analysis of revised water heater standards should be based on installed costs of replacement water heaters only. (GAMA, No. 51 at 3–4). DOE used the same installation costs for both markets. We based these costs on replacement costs because there are no cost installation data for new construction. New construction costs are combined with the plumbing and venting costs and we could not separate out the water heater installation costs.

Installation Cost for 3 Inch Thick Insulation. Thicker insulation creates a larger water heater than the typical unit sold today. VP claimed we should account for the impact of increasing unit size on installation ease and cost in replacement applications. (VP, No. 45 at 3). Rheem and SC claimed customers should not have to knock out walls and ceilings or relocate a water heater during replacement. (Rheem, No. 95 at 1 and SC, No. 84 at 2).

From the Residential Energy Consumption Survey (RECS) 1993 public use data, 54% of water heaters are located in a conditioned space. We assumed at least 50% of those homes would need the closet or an attic door removed to facilitate water heater replacement installation for 3 inch thick insulation. We estimated this cost at $160 using responses from water heater installers and the 1996 Craftsman National Construction Estimator. This installation cost is for the removal and replacement of door jambs for 50% of all water heaters located in a conditioned space. We assumed oil-fired water heaters are not installed in conditioned spaces and therefore this cost is not applicable to oil-fired water heaters.

We also do not believe people should have to knock out ceilings or walls to replace a water heater. Therefore, we investigated the impact of reducing tank volume by 20% on the first hour rating. The first hour rating is a measure of how much usable hot water can be supplied by a water heater in one hour starting from a fully heated tank. It is determined by the DOE test procedure. We believe that increasing the heating element from 4.5–6 kW can adequately compensate for the 10 gallons of storage volume lost by a 20% reduction in a 50-gallon electric water heater. We also believe that a similar increase in gas burner input rate can achieve the same effect with gas-fired water heaters.

Venting Costs. If people replace their gas-fired water heater located in a conditioned space with one which has a higher RE, then there may be additional installation costs. In an attempt to account for these costs, DOE assumed a Type-B vent connector is installed when replacing an existing gas-fired water heater located in a conditioned space with a water heater with an RE of 78%, in 25% of homes in climate regions exceeding 5,000 heating degree days. Note that heating degree days are the number of degrees the average temperature is below 65°F. For water heaters with flue baffles that achieve 80% RE, we assumed a Type-B vent connector is installed and a masonry chimney is relined when replacing an existing gas-fired water heater located in a conditioned space in 25% of homes in climate regions exceeding 5,000 heating degree days. In comments, Bradford White, LaClede and CNG stated we must add more installation cost to gas-fired and oil-fired water heaters for larger diameters and heights, pressure and temperature relief valves, relining masonry chimneys and for condensate removal. (Bradford White, No. 74 at 3; LaClede, No. 69 at 6; and CNG, No. 85 at 2).

DOE believes we have accounted for the installation costs associated with higher RE gas-fired water heaters. We used installers' estimates to calculate the cost of installing Type-B vent connectors and to determine the cost to reline masonry chimneys. These estimates are slightly higher than the GRI estimates. We estimated the number of homes needing Type-B vent connectors for 78% RE gas-fired water heaters from comments, and from an AGA survey in a GRI report. (GRI–91/0298). We also used the AGA survey data to determine, by region, the number of water heaters connected to masonry chimneys. In the same manner, we estimated installers would reline 25% of the masonry chimneys in climate regions exceeding 5,000 heating degree days when replacing an existing gas-fired water heater with an 80% RE water heater. DOE developed its installation costs for Type-B vent connectors and masonry chimney relining based on the replacement market and installers' cost estimates for a typical installation, which would include the pressure and temperature relief valve. See Appendix D–3 in the TSD.

We did not raise the RE enough to create condensation nor do we anticipate higher installation costs for 2 or 2.5 inch insulation thicknesses. Therefore, we added $160 for removal and replacement of door jambs for 50% of gas-fired water heaters with 3 inch thick insulation located in conditioned spaces. From the GRI data, we estimate that 25% of households with gas-fired water heaters in regions with over 5,000 heating degree days would need Type-B vent connectors at a cost of $114 for 78% RE. We estimated that 25% of households with gas-fired water heaters in regions with over 5,000 heating degree days would need chimney relining at a cost of $433 for 80% RE gas-fired water heaters. This is about one-half of the households with gas-fired water heaters common vented with gas furnaces.

Cost to Install Electricity. The three remaining gas-fired water heater design options (electronic ignition, electro-mechanical flue damper, and side-arm heater) all require electricity to operate. We used data from GRI to estimate the number of households that would require electricity. We also used GRI data to estimate the cost of labor and wiring and adjusted these estimates for inflation to obtain 1998 cost estimates, see Chapter 8.4.5 in the TSD for more details.

e. Maintenance Costs

The electro-mechanical flue damper and the side-arm heater are the only design options that increase a gas-fired water heater's maintenance cost. We used the TSD water heater analysis for the March 4, 1994, NOPR to estimate the maintenance cost of the flue damper. (59 FR 10464, March 4, 1994) In this analysis, we assumed the flue damper failed in the tenth year of operation. We discounted the maintenance cost of the flue damper at a 6 percent rate to get its present value in 1998 dollars.

In response to a comment from Battelle, we included the maintenance cost to replace the side-arm heater circulation pump. (Battelle, No. 66 at 9 and No. 83 at 11). We assumed 10% of the installations would require a replacement of the circulation pump each year. We estimated the cost using contractor estimates and the 1998/99 Grainger Catalog.

The intermittent ignition device (IID) of gas-fired water heaters may incur maintenance costs due to the failure of the control module or the sensor. We assumed the IID maintenance cost to be equivalent to the maintenance cost of replacing the standing pilot light and therefore did not assign any incremental cost to it.

With the exception of the electro-mechanical flue damper, the IID and the side-arm circulation pump, information gathered to date suggests there is virtually no maintenance of residential electric or gas-fired water heaters. However, there were some suggestions from the manufacturer interviews that side-arm gas-fired water heater designs may incur increased maintenance costs due to clogging of the heat exchanger from scaling associated with hard water, but no data were identified or provided to confirm this.

We included a typical annual maintenance charge for oil-fired water heaters. Since we anticipate that none of the oil-fired water heater design options will affect maintenance, this charge has no bearing on the final engineering analysis of the design options.

f. Determination of Markups for Retail Prices

The retail price is the consumer cost of the water heating equipment. We determined the retail price for any design option simply by multiplying the manufacturer cost by the derived markup for the particular product class. We obtained a manufacturer cost-to-retail price markup by dividing the retail price by the manufacturer cost. We performed this calculation separately for electric, gas-fired, and oil-fired water heaters. In the engineering analysis, we assumed that the baseline manufacturer cost-to-retail price markup was constant for all design options within a fuel class. Our approach results in different average markups for each fuel class in the engineering analysis.

In order to obtain the retail price, DOE created the Water Heater Price Data Base. This Data Base contains extensive data on retail prices for electric and gas-fired water heaters and very limited information regarding retail prices of oil-fired water heaters. While the data in the Water Heater Price Database are based on information from water heater vendors in many regions of the U.S. (e.g., large retailers, plumbing wholesalers, small suppliers, web-sales and utility representatives), the majority of price information was gathered from large retailers and plumbing wholesalers. Although the database lacks information on the number of specific models sold, it contains actual prices representative of many models. We received the oil-fired water heater retail prices from approximately 25 oil equipment installers who buy water heaters from manufacturers and sell directly to consumers. In the case of oil-fired water heaters, the retail price does not include the cost of the burner, which is typically purchased separately.

We determined an average price for an existing baseline 50-gallon electric, 40-gallon gas-fired, or 32-gallon oil-fired water heater with HCFC–141b foam insulation . Since the length of the manufacturer's warranty affects the price of the water heater, we originally considered only water heaters with a five year or less warranty as baseline models. However, at the November 1998 workshop, water heater manufacturers provided information that six-year warranties are typical of those models that are produced in large quantities (i.e., baseline models). A longer warranty period, in addition to raising the price, also may indicate the presence of some design features not normally found in baseline models. Based on this information, we have changed the analysis to include water heaters with warranties of six-years or less in our baseline models.

The Water Heater Price Database includes installation costs that are part of the total cost to consumer. This price includes miscellaneous fees such as the delivery fee, removal fee, permit fee, and parts fee. We applied additional installation costs to some design options'for example, to account for replacing vent connectors, relining masonry chimneys, or installing larger water heaters in small spaces.

In their comments, AGA and EMPA claimed the database is not representative of all manufacturers or states. (AGA, No. 49 at 5; EMPA, No. 50 at 3; and No. 88 at 4–6). NEEA, NWPPC, ACEEE, Pacific Gas and Electric (PG&E) and OOE claimed DOE's retail prices are too high or DOE's incremental costs are too large. They cited data from the Eugene, Oregon Water and Light Board or the California Residential Contractors Program. (NEEA, No. 53 at 2; NWPPC, No. 43 at 2; ACEEE, No. 52 at 6 and No. 93 at 4; PG&E, No. 94 at 4; and OOE, No. 44 at 6; and No. 76 at 10). We received comments regarding the basis of the markups. For example, the analysis only included water heaters sold through stores (ACEEE, No. 52 at 6); the data may have been skewed by high sales volume models used as loss leaders (GAMA, No. 71 at 1); and the markup results should be reasonably consistent with prices found in the Northwest. (OOE, No. 44 at 7).

In response to these comments DOE collected more data to make the database more representative. DOE added more retail price data from wholesalers and plumbing distributors. DOE added price data from the Eugene Water and Light Board's database but DOE added only a limited number of these prices so that its database would continue to be representative of regional populations in the entire U.S. Nevertheless, the addition of these data did not significantly change the average retail price of gas-fired or electric water heaters. DOE believes its price database, from more than 130 retail distributors and plumbing wholesalers (representing all 12 Census divisions and all five major manufacturers), provides an accurate representation of prices with good regional representation.

OOE claimed a constant price should not be used for the entire analysis period because water heater prices should match today's prices in the mature market of the Pacific Northwest within 5–7 years after the imposition of a standard. (OOE, No. 96 at 6). We appreciate the price data provided by OOE and we have used a portion of the data in our national Water Heater Price Database. However, we kept the prices representative of each region in the U.S. by maintaining a fixed relationship between the number of water heater prices and the population of each region. See Chapter 5.2 in the TSD.

We obtained a manufacturer cost-to-retail price markup by dividing the retail price by the manufacturer cost. Our approach results in different average markups for each product class (i.e., 1.49 for electric, 1.22 for gas-fired, and 3.2 for oil-fired water heaters).

Since oil-fired water heaters are essentially a niche product, the large markup was not surprising. However, several commenters believed that the gas-fired water heater markup should be nearly identical or identical to the electric water heater markup. ACEEE commented that DOE's retail costs showed inconsistent markups between electric, gas-fired, and oil-fired water heaters. (ACEEE, No. 52 at 6). GAMA claimed the markup value for gas-fired water heaters was too low because DOE only sampled the retail market and some of the models are direct vent models. (GAMA, No. 51 at 4). GAMA, AGA, EPRI, SC, CNG, and Bradford White suggested DOE apply the same markup to electric and gas-fired water heaters. (GAMA, No. 51 at 4; AGA, No. 49 at 5; EPRI, No. 70 at 3; SC, No. 72 at 2; CNG, No. 85 at 3; and Bradford White, No. 74 at 3). VP claimed there is no justification for using one average markup. (VP, No. 45 at 2). Battelle claimed the gas-fired water heater markup is too low. (Battelle, No. 83 at 8). SC did not believe retail markups for electric water heaters are twice as high as those for gas-fired water heaters. (SC, No. 84 at 1). EPRI disagreed with DOE's markup approach because it raises the price of heat traps differently for each fuel and tank size. (EPRI, No. 41 at 4).

We derived the markups by comparing retail prices to the baseline costs provided by GAMA. We believe these prices are representative of the national market for residential water heaters. Additionally, we applied our approach uniformly to all fuel types. Chapter 5 of the TSD provides a discussion on retail prices.

E. Economic Analysis

1. Life-Cycle-Cost (LCC) and Payback Analysis

In determining economic justification, the Act directs the Department to consider a number of different factors, including the economic impact of potential standards on consumers. Section 325(o)(2)(B)(i)(I), 42 U.S.C. 6295(o)(2)(B)(i)(I). The Act also establishes a rebuttable presumption that a standard is economically justified if the additional product costs attributed to the standard are less than three times the value of the first year energy cost savings. EPCA, § 325(o)(2)(B)(iii), 42 U.S.C. 6295 (o)(2)(B)(iii).

The payback, for purposes of the rebuttable presumption test, attempts to capture the payback to consumers affected if a new standard is promulgated. It compares the cost and energy use of water heaters consumers would buy in the year the standard becomes effective with what they would buy without a new efficiency standard. DOE calculates a simple payback which is the ratio of the increase in purchase price (including installation) to the decrease in annual operating expense (including maintenance).

In considering this factor, the Department calculates changes in LCCs to the consumers that are likely to result from the proposed standard and two different simple payback periods: the median payback period and the test procedure payback period. The difference between these payback calculations is due to the way we calculate energy savings. The median payback is based on the LCC analysis using a derived amount of hot water dependent on characteristics of each household. The test procedure payback is based on hot water usage of 64.3 gallons per day, the estimate of hot water usage used in the DOE test procedure.

The effect of standards on individual consumers includes a change in the operating expense (usually decreased) and a change in the purchase price (usually increased). The net effect is analyzed by calculating the change in LCC as compared to the base case. Inputs to the LCC calculation include the installed consumer cost (purchase price plus installation cost), operating expenses (energy and maintenance costs), lifetime of the appliance, and a discount rate.

In addition to analyzing price and energy cost effects on each household in a national database, DOE also determines which segments and what size of the population, if any, may be adversely affected. The Department has decided to consider the LCC impacts on low income and seniors-only consumer subgroups in this rulemaking. We chose the low-income subgroup because higher water heater prices might affect that subgroup more than the general population. We chose the seniors-only subgroup because many of them may be in the low-income subgroup and because they tend to use less hot water than the general population. Lower water usage could increase the payback of some efficiency improvements.

The LCC and one of the payback periods (median payback) are calculated using the LCC spreadsheet model developed in Microsoft Excel for Windows 95, combined with Crystal Ball (a commercially available software program) based on actual distributions of input variables. The LCC outputs from this program are a range of values that allow us to determine what fraction of the population will benefit from energy efficiency standards.

Based on the results of the LCC analysis, DOE selects candidate standard levels for a more detailed analysis. The range of candidate standard levels typically includes: (1) the most energy-efficient combination of design options or most energy-efficient level; (2) the combination of design options or efficiency level with the lowest LCC; and (3) the combination of design options or efficiency levels with a payback period of not more than three years. Additionally, candidate standard levels that incorporate noteworthy technologies or fill in large gaps between efficiency levels of other candidate standards levels may be selected. 10 CFR Part 430, Subpart C, Appendix A(5)(c)(3).

Table 4 lists the major input distributions DOE used in the water heater LCC analysis for the HFC–245fa blowing agent. We also completed an analysis for water blown insulation in the TSD. We discuss many of these assumptions briefly in this section. For more details on the LCC analysis for both blowing agents, please see Chapter 9 in the TSD.

TABLE 4.—INPUT DISTRIBUTION USED IN THE LCC ANALYSIS

LCC analysis assumptions	
Description	Assumption
Blowing agent	HFC–245fa blowing agent.
Energy prices	Marginal energy prices for incremental cost savings; average energy prices for base line costs.
Future energy prices	AEO99 reference case to the year 2020 with extrapolations to the year 2030.
Discount rates	0–15% with an average about 6%.
Water heater prices	From the engineering analysis.
Installation costs & baseline retail prices	LBNL water heater price database.
Design option combinations	From the engineering analysis.

LCC Analysis Assumptions

Description	Assumption
Markup	Retail prices divided by GAMA's manufacturing costs, calculated for each house in RECS '93.
Household characteristics	1993 RECS public use database, 5222 households.
Lifetime	Electric, 4–19 years, most likely 12 years; gas and oil, 3–15 years, most likely 9 years.
Energy consumption	Using RE, standby losses and input heating rates from the engineering analysis and calculated with WHAM.
Daily hot water use	Based on number of people, tank size and type of appliances from RECS, and thermostat settings and location imputed from the RECS data; climate data from NOAA 30 year averages; inlet water temperature and air temperature based on climate data.

To get data representative of all U.S. residential households we used DOE's Energy Information Administration (EIA) *Residential Energy Consumption Survey* (RECS) for 1993. The RECS public use data survey weights each household so that the data properly represent the 96.1 million households in the 50 states and the District of Columbia. The 1993 RECS public use data survey provides information concerning energy consumption in the residential sector and contains a more complete set of data for water heater analysis than any other survey reviewed and available for this study. The survey contains basic data concerning household characteristics from an interview questionnaire and annual fuel consumption and expenditures (excluding transportation fuel) derived from the records of fuel suppliers. It also includes weather data (in the form of heating and cooling degree days) and a weighting variable. The households included in the analysis (75% of the RECS public use data) all have running hot water, and an individual water heater using one of four fuels: electricity, oil, natural gas, or LPG. Households without these features, which did not report their water heater size, or for which a marginal energy price could not be calculated, are not used in the analysis.

The Department has received comments concerning the RECS data. EMPA claimed the 1993 RECS public use data is not valid, reliable, or representative because the useable data on electricity and gas consumption and costs is from only a portion of the households. (EMPA, No. 88 at 6). The RECS public use data is the most comprehensive national data set concerning residential water heating energy use. DOE used the entire data set that pertains to the types and sizes of water heaters in this rulemaking. We believe this subset is nationally representative and thus a valid data set.

a. Marginal Energy Price

DOE formerly used average energy prices, but stakeholders objected because these prices did not represent a consumer's true savings. For the LCC analyses, the Advisory Committee on Appliance Energy Efficiency Standards recommended DOE use the full range of consumer marginal energy prices instead of national average energy prices. Marginal energy prices are those prices consumers pay (or save) for their last units of energy used (or saved). The Department agreed that marginal energy prices would improve the accuracy of the LCC analysis and estimated marginal rates for electricity and natural gas from the 1993 RECS database.

EIA gathered monthly energy bills and energy consumption data for the RECS public use data. It did not gather information on rate schedules, fixed charges, or marginal prices. DOE estimated consumer marginal electricity and natural gas prices directly from household data in the 1993 RECS public use data survey as the change in household monthly energy bills divided by the change in monthly energy consumption for each fuel, referred to as the change in monthly bill method. This provides a precise marginal energy rate based on actual household bills.

For electricity, DOE calculated the slopes of the regression lines for four summer months (June–September) and, separately, for the winter (October–May) months. DOE derived the annual marginal price by taking the weighted average of the two seasonal prices, where the weighting used was the relative energy consumption of the appliance in each season. For water heaters, the weighting was 28% summer and 72% winter. For natural gas, DOE calculated the slopes of the regression lines at the annual level because there was no seasonal difference in marginal gas prices.

In order to understand and characterize regional variations in pricing and distribution of fuel oil and LPG, we collected information relating to pricing and distribution of fuel oil and LPG. We learned that bills paid by residential consumers for both fuel oil and LPG are essentially volume-driven, with a single block rate. We interpreted the average prices inherent in those bills, as reported in the RECS public use data, as being equivalent to marginal prices for the purposes of the LCC price analysis.

Several stakeholders commented on DOE's marginal energy prices. EEI and LaClede commented that marginal rates from the RECS public use data did not agree with EEI or AGA estimates. (EEI, No. 67 at 1–2; and LaClede, No. 82 at 2). EEI claimed DOE overstates actual electric costs by 12.8% due to the use of Inflator93. (Inflator93 is a scaling factor DOE used in an earlier analysis to adjust electricity prices from 1993–1998.) (EEI, No. 67 at 1–2). EMPA claimed that DOE did not account for the sampling and non-sampling errors in the RECS public use data and that DOE included fixed costs. (EMPA, No. 88 at 6–7).

We discovered that the Inflator93 coefficient in the July 1999 Workshop Analysis was incorrect and we removed it. There is no direct comparison between DOE's change in monthly bill method and EEI's and AGA's method of subtracting fixed costs because of differences in the level of aggregation (rate class vs. individual households), sample set, and time period. Furthermore, DOE believes a marginal energy price based on subtraction of fixed costs is not correct due to variable rate schedules and seasonal rates. DOE's change in monthly bill method can and does account for variable rates and seasonal rates.

VP stated that statistical probability analysis on many of the analysis inputs, use of marginal energy prices, and accurate conversion efficiencies provide greater assurance that the final rule will be appropriate and not overly burdensome. (VP, No. 45 at 3). DOE believes this is true. Our analysis methodology uses distributions on many analysis inputs, marginal energy prices and conversion efficiencies which change during the analysis based on EIA forecasts.

We recognize there are sampling and non-sampling errors in the RECS public use data. However, these errors are small and we expect they will have very little impact on marginal energy rates. For example, EIA compared the results from RECS with the American Housing Survey results and found the maximum difference between the two surveys was 3.2%. EIA also compared results to Consumer Expenditures (CE) estimates by the Bureau of Labor Statistics and found fuel expenditures for the CE were 2% higher for gas and 6% higher for electricity.

DOE used projected future trends in average energy prices to derive estimates of future consumer marginal energy prices for the economic analysis of proposed standards. We created an index (scaling factor) from the trend in average prices (by fuel and sector) and applied it to the 1993 marginal prices calculated from the RECS public use database. The index accounts for both inflation and real energy price changes and it is different than Inflator93. For example, the average residential electricity price declined by 20% from 1993–1998, so we assume the marginal price for each household declines by 20% over the same period of time.

b. Future Energy Prices

Given the uncertainty of projections of future energy prices, DOE used scenario analysis to examine the robustness of proposed energy efficiency standards under different energy price conditions. The LCC calculations used these scenarios. Each scenario integrates energy supply and demand into its energy price. The scenarios differ in the energy prices that result. The Advisory Committee on Appliance Energy Efficiency Standards suggested the use of three scenarios with high, low, and middle levels of energy prices because three scenarios should be sufficient to bound the range of energy prices. This is also the guidance provided in the Process Rule, 10 CFR 430 subpart C, appendix A 13(b).

The EIA's 1999 Annual Energy Outlook (AEO99) reference case provides a middle scenario. For the high and low energy price scenarios, DOE used the scenarios with the highest and lowest energy prices in the economic sector and the fuel of interest from AEO99. DOE also used the reference case from the GRI projection, 1998 GRI Baseline Projection: Residential Natural Gas, Electricity, and Distillate Fuel Oil Prices Tables. The future trend in energy prices assumed in each of the four scenarios is clearly labeled and accessible in each spreadsheet. Stakeholders can substitute alternative assumptions in the spreadsheets to examine additional scenarios as needed.

c. Discount Rates

The Process Rule states that DOE will establish real (adjusted for federal taxes) discount rates for residential consumers by considering a range of three different real discount rates: credit card financing rate, a rate based on consumers having substantial savings, and a mid-range rate. 10 CFR 430, subpart C, appendix A13(d). The mid-range discount rate will represent DOE's approximation of the average financing cost (or opportunity cost of reduced savings) experienced by typical consumers.

Based on the guidelines from the Process Rule, we derived a distribution of discount rates to reflect the variability in financing methods consumers can use in purchasing water heaters. The real interest rate associated with financing an appliance purchase is a good indicator of the additional costs incurred by consumers who pay a higher first cost, but enjoy future savings, although it is not the only indicator of such costs. While the method used to derive this distribution relies on a number of uncertain assumptions regarding the financing methods used by consumers, DOE believes the resulting distribution of discount rates encompasses the full range of discount rates that are appropriate to consider in evaluating the impacts of standards on consumers (*i.e.,* values represented by the mid-range financing cost, consumers with no savings, and consumers with substantial savings), as well as all the discount rates that fall between the high and low extreme values.

DOE assumes the method of purchase used by consumers is indicative of the source of the funds and the type of financing used, although DOE is not aware of detailed research into this relationship. Whirlpool Corporation indicated that approximately 40% of white goods are purchased in cash, 35% with credit cards, and 25% with retailer loans. (1994 Eight Product Notice of Proposed Rulemaking, 59 FR 10464, March 4, 1994.) The same manufacturer indicated that 25% of appliance purchases are for new homes. However, we know consumers purchase 20% of water heaters with new homes, *i.e.,* in mortgages, and 80% as replacements for existing water heaters in separate retail purchases. Consumers pay for retail purchases by cash, credit cards, or loans. In the case of water heating equipment, we assumed consumers would usually use credit cards because most water heater purchases are emergency replacements. In order to derive a full distribution of discount rates, DOE estimated a range of interest rates, based on historical data and judgments of future trends, for different types of consumer savings or financing.

For new housing, the estimated nominal mortgage rate ranges from 5–8%, the derived after-tax rate is based on a tax of 28%, and a 2% inflation rate is subtracted from the total. The result is a range of real mortgage rates from 1.60%–3.76%. Example: 5%*(100%–28%)–2% =1.6%.

For cash, the minimum interest rate is 0%. This rate applies to consumers making cash purchases without withdrawing from savings accounts or interest bearing checking accounts. For the maximum rate, the opportunity cost is the interest that could have been earned in a savings account or mutual fund. The historical nominal maximum savings rate ranged from 4.5–5.5% from 1970–1986 (real rates of –8.27 to +3.58%). We believe the current maximum is the opportunity cost represented by the interest earned in a typical mutual fund (assumed to be 6% real). DOE selected a real rate of 3% as the mean.

DOE assumed the interest rates for retail loans and credit cards have the same range. The minimum credit card rate is 6% real. Introductory rates on some credit cards today are 5.9% nominal, but after the introductory period (often six months), the rate can increase sharply. Maximum rates are more than 20% nominal. However, if the consumer pays with a credit card and the balance is paid in less than the life of the water heater, then the effective interest rate is lower than the nominal credit card rate. The current assumption is a range of 6–15% real.

Combining the assumed shares of each financing method, the above real interest rates result in a weighted-average (mean) value of 6% and a distribution that varies from 0–15%. Sensitivity studies show that while the LCC results are sensitive to the value chosen for the mean discount rate, the LCC results are not sensitive to the distribution of discount rates.

DOE believes the methods described above are valid for establishing a distribution of discount rates relevant to most purchasers of the products covered by this rulemaking. However, the Department acknowledges that different assumptions could be made about likely interest, inflation and marginal tax rates, or about consumer financing methods, and that different approaches to identifying consumer discount rates might also be valid. For example, it is possible to base consumer discount rates on the average real rates of return on consumer investment or other measures of the opportunity costs incurred by consumers who purchase the covered products. DOE does not believe, however, such alternative assumptions or alternative approaches would significantly alter the range of discount rates used by the Department or the conclusions drawn from the LCC analyses conducted using these discount rates.

The Department is seeking any information that would support significant alterations in the range or distribution of the discount rates derived from its analysis. Alternatively, DOE is soliciting comment on the possible use of a standardized distribution of discount rates ranging from approximately 4–12%, with a mean of 6%. The use of such a standardized distribution would explicitly recognize the many uncertainties associated with DOE's current analysis and, based on sensitivity analyses already performed by DOE, such a standardized distribution would not significantly alter the conclusions of DOE's life cycle cost analyses.

Two stakeholders, EEI and EMPA, claimed the discount rates in the LCC appear to be very low for consumers. (EEI, No. 39 at 7 and EMPA, No. 50 at 2). They do not reflect the actual consumer purchasing behavior as measured by an implicit discount rate. Such discount rates are often higher. DOE policy is to base discount rates on average financing costs (or opportunity cost of reduced savings) experienced by typical consumers.

d. Household Characteristics

The 1993 RECS public use data provide a sample of 7,111 households from the population of all primary, occupied residential housing units in the U.S. Of the 7,111 households, we use 5,222 household records in the analysis and we assume these households are representative of housing on a national scale. The households included in the analysis (see Table 5) have four defining features:

1. Water heater size
2. An individual water heater
3. One of four fuels: electricity, oil, natural gas, LP gas
4. Billing data for electric and gas-fired water heaters and gallons of fuel oil or LPG used

Of the households not included, 11.8% shared water heaters or used other fuels; these water heaters are not subject to this rulemaking. Of the remaining households not included, 6.2% had no water heater size indicated and 8.2% had insufficient billing data for energy price analysis.

EEI commented that the RECS public use data are more than five years old. (EEI, No. 39 at 3 and No. 67 at 1). The detailed 1997 RECS public use data were released in mid-January 2000. However, the Department has not had an opportunity to analyze the impact at this time. We will, however, determine the impacts of this updated information for the final rule. We have accounted for the age of the energy price data by adjusting the 1993 data to represent 1998 prices. We did this by multiplying the 1993 data by the ratio of the average annual energy prices from the EIA AEO between 1993 and 1998.

Table 5 provides some information about households in the 1993 RECS public use data used in the LCC analysis. The weighted number of households are the total households represented by the RECS data. The average hot water use is not from RECS but is determined from the results of a California Energy Commission (CEC) study of hot water usage. We have included the average water heater set point and average inlet water temperature, which are not part of the RECS public use data. These are derived from the location of the household using the National Oceanic and Atmospheric Administration's (NOAA) 30-year (1961–1990) database of average air temperatures to estimate average annual outdoor and inlet water temperatures (NOAA database: www.ncdc.noaa.gov/ol/climate/online/ccd). A more complete discussion of the data not from RECS is found in section III.E.2.d., Energy Analysis Module.

TABLE 5.—1993 RECS HOUSEHOLD CHARACTERISTICS

	Gas	Electricity	LPG	Fuel Oil	All Fuels
Number of Households (records)	2475	2323	248	176	5222
Number of Households (weighted)	35,959,707	30,279,600	2,540,960	1,807,350	70,587,617
Household Size (average number of people)	2.79	2.58	2.70	2.87	2.70
Clothes Washer (percent saturation)	89.2	82.0	89.1	96.6	86.3
Dishwasher (percent saturation)	52.4	49.1	32.5	56.8	50.4
Average Thermostat Set point (deg F)	134.6	133.5	135.0	137.5	134.2
Average Inlet Water (deg F)	57.1	59.1	56.3	51.8	57.8
Average Hot Water Use (gallons per day)	48.6	45.4	47.3	47.3	47.1
Low Income Households (percent of total)	5.68	5.69	0.64	0.12	12.13
Senior-Only Households (percent of total)	8.13	7.66	0.72	0.39	16.90
Senior-Only and/or Low income (percent of total)	12.59	12.17	1.17	0.492	6.42

Stakeholders raised concerns about the RECS data. Battelle commented that some fraction of households in the RECS database incorrectly identifies fuel type of water heaters. (Battelle, No. 66 at 5).

Battelle and AGA claimed DOE ''fabricated data not in the database.'' They believe this has led to higher average set point temperatures for gas water heaters (134.5°F for gas vs. 133.7°F for electric), cooler air temperatures where the water heater is installed (55.1°F for gas vs. 56.7°F for electric), and colder entering water temperatures (57.3°F for gas and 58.7°F for electric). (Battelle, No. 83 at 2 and AGA, No. 92 at 3).

Set point temperature, air temperatures and entering water temperatures are not in the RECS database. To obtain the set point, air and entering water temperatures, the Department used the following approach. DOE used heating degree days to determine an approximate location for each household. This is necessary because household locations are confidential. Based on the location, we used the 30-year NOAA data to determine the average air temperature. We derived cold water inlet temperatures based on the average annual air temperature. (NOAA database: www.ncdc.noaa.gov/ol/climate/online/ccd). From a study by the CEC (CEC, 1990, Report No. P400–90–009), DOE has inferred the set point temperature based on the cold water inlet temperature. This methodology is applied equally to all of the RECS public use data—gas, oil and electric. Any difference in the results among fuels is due to regional differences of saturations of water heater fuel types and not to the data that DOE uses.

Battelle disagreed with DOE's preliminary results showing average daily water use of 48.5 gallons per day for households with gas-fired water heaters versus 45.4 gallons per day for households with electric water heaters. Battelle claimed DOE's results will increase the energy used by 3.3% and will cause 3.2% more standby losses for gas water heaters. (Battelle, No. 83 at 3). DOE believes the differences in average energy use and standby losses between gas and electric water heaters are due to regional differences in numbers of water heaters by fuel type and household size, among other factors. These differences are not caused by inadequate data.

e. Lifetime

Appliance Magazine was the source of information for water heater lifetimes. We created a triangular distribution using 4–19 years as the base for electric water heaters and the most likely value of 12 years as the peak. Similarly, for gas-fired water heaters the base is 3–15 years with the most likely value at 9 years. We assumed that oil-fired water heaters have the same lifetime as gas-fired water heaters.

2. LCC Spreadsheet Model

In order to simplify handling large amounts of input data, the water heater LCC analysis spreadsheet has five modules. The modules are LCC and Payback, Equipment Cost, Operating Cost, Energy Analysis, and Hot Water Draw. Chapter 9 in the TSD contains a detailed discussion of the spreadsheet and the individual modules.

a. LCC and Payback Module

The LCC analysis uses a spreadsheet model developed in Microsoft Excel combined with Crystal Ball (a commercially available software program). The model uses a Monte Carlo simulation to perform the analysis while considering uncertainty and variability of many input values. Crystal Ball is a program that provides risk analysis capabilities to help analyze the variability and uncertainties associated with the data. We organized the spreadsheet so ranges (distributions) are entered for each input variable needed to perform the calculations.

Recognizing that each household is unique, we accounted for variability in the model by performing the LCC calculation for a large number of individual households. The Monte Carlo simulation samples individual households from the RECS public use data. The results show the fraction of households having a particular LCC and payback.

For the LCC calculations, we randomly sampled the set of households 10,000 times. The analysis used separate LCC spreadsheets for each fuel type (electricity, natural gas, and fuel oil) and blowing agent (water and HFC–245fa). Chapter 9.1 of the TSD describes the sampling methodology and contents of the RECS public use data.

In comments, EMPA claimed 10,000 Monte Carlo runs are not enough, and consumers' actual savings depend on their specific energy prices and amount of usage of the appliance. (EMPA, No. 88 at 2–7). AGA claimed manufacturers' costs and consumer prices are correlated so DOE should use a correlated Monte Carlo approach. (AGA, No. 92 at 5).

We believe 10,000 Monte Carlo runs are sufficient because, when tested at 20,000 runs, there was less than 1% difference in the results. The manufacturers' cost data is not connected with a specific model but is only provided as a cost distribution. Therefore, manufacturers' costs and the prices in the Lawrence Berkeley National Laboratory (LBNL) price database cannot be correlated. There is no one-to-one correlation between the cost of a specific model to the price for that same model because GAMA only provided cost distribution data.

We analyzed all design options for water heaters as if they were at production levels equivalent to the typical existing baseline models, i.e., possessing similar economies of scale. We performed the LCC analysis separately for each energy source: electric, gas (including LPG) and oil. We calculated the analysis twice, once for water-blown insulation and again for HFC–245fa blown insulation. The LCC analysis does not address fuel choice; this is addressed in Section F, National Energy Savings and Shipments. See Section IV.A.1.a of this notice for the results of the LCC analysis.

The Department calculates payback and LCC for each design option combination and compares it to the 2003 baseline model for every sample household.

b. Equipment Cost Module

Equipment cost represents the sum of the retail price, sales tax, and installation costs. We calculated the retail price from the manufacturer's cost multiplied by an overall markup. GAMA provided estimates of water heater manufacturing costs for typical existing baseline models. The source of the retail price, the sales tax, and the installation cost of existing baseline models is the Water Heater Price Database, which is described in Section III.D.3.e. See Chapter 5.3 of the TSD.

In its analysis for the November 1998 workshop, we estimated the manufacturing costs for all other standard size existing baseline water heaters based on the manufacturing cost for the typical water heater plus (or minus) incremental costs for extra foam insulation, sheet metal, and other components. We determined the retail price of each combination of design options by multiplying the manufacturing cost times the markup. See Chapter 7 on markups and Chapter 9.5 in the TSD for a complete discussion of this.

AGA claimed DOE used average markups in the LCC. (AGA, No. 92 at 5). DOE does not use average markups in the LCC. As described above, we calculate an overall markup for each RECS household by dividing a randomly chosen retail price from the Water Heater Price Database by a randomly chosen manufacturing cost from the cost distribution data for each standard-size existing baseline model. We apply this markup to all of the subsequent design options for that household. We limited the markup algorithm to ensure the retail price was never lower than the manufacturing cost.

c. Operating Cost Module

Operating a water heater involves two costs: Fuel to operate the water heater and maintenance to keep the water heater running properly. Fuel costs depend on the water heater's energy usage and the per-unit cost of fuel. Maintenance costs depend on water heater design and were determined from consultants' discussions with manufacturers and installers.

In the LCC analysis, we calculate the operating cost for the baseline product class (fuel type) for each household in the RECS database using average annual energy prices. For each design option or combination of design options, we multiply the energy savings by the marginal energy price. The operating cost is the baseline operating cost minus the operating cost savings for the particular design option or combination of design options. Therefore, we apply marginal energy prices to only the portion of total operating cost resulting from improved energy efficiency.

To account for future uncertainties, we apply various scenarios of projected future energy prices (trends by national average) to each household's marginal energy price. After we adjusted for inflation and energy price changes, we adjusted energy prices for the RECS public use data from the starting year by the projected average future energy prices. Thus, each sample house from the RECS public use data has four different future annual energy price series associated with it. We estimated future annual operating costs as annual energy use multiplied by the annual energy price series for each of the four scenarios: AEO99 High Growth, AEO99 Reference Case, AEO99 Low Growth, and the 1998 GRI Baseline Projection. The user can choose from among these four scenarios in the spreadsheets or can input his or her own price forecast.

d. Energy Analysis Module

Since we can write WHAM as an equation, DOE used it in the LCC spreadsheets to quickly and reliably estimate residential water heater energy consumption. We validated WHAM with the TANK and WATSIM simulation programs for gas-fired and electric water heaters for many water heater characteristics. The WHAM results were within 3% of predicted energy consumption for electric, and within 5% of predicted energy consumption for gas-fired water heaters. Three parameters—RE, UA and rated input power—describe the efficiency characteristics of the water heater. The operating conditions of the water heater are the average daily hot water used, inlet water temperature, hot water outlet temperature, and air temperature around the water heater.

We used the RE and standby heat loss coefficient values from computer simulations developed for the Engineering Analysis and rated input power from manufacturers' product literature to describe the energy performance of water heaters.

WHAM uses the average daily hot water consumption for each household calculated by the Hot Water Draw Module, discussed below. We calculated temperatures for inlet water and the air surrounding the water heater from the outdoor air temperature and the location of the water heater in the house. The RECS public use database provides data on heating and cooling degree days, but not air or water temperatures, for each household in the sample. Each household was assigned to the climate zone within its reported Census division with the closest number of heating and cooling degree days for 1993. Once each household was associated with a climate zone, we made other temperature assignments from NOAA's 30-year average annual temperatures. (NOAA database: www.ncdc.noaa.gov/ol/climate/online/ccd).

To assign hot water outlet temperatures for households, we derived an equation from a CEC study that measured delivered water temperature and cold water temperatures. (CEC, 1990, Report No. P400–90–009) The equation derived from the CEC data indicates that the water heater set point varies inversely with inlet water temperature. For every degree the average inlet water temperature increases, the hot water set point temperature decreases about half a degree. See Chapter 9.3.4 in the TSD for a discussion of the CEC data.

e. Hot Water Draw Module

Hot water use varies widely among households because it is dependent on household and water heater characteristics, including the number and age of the people who live in the home, the presence of appliances using hot water, the tank size and thermostat setting of the water heater, and the climate in which the home is situated. By accounting for these five characteristics, the hot water draw model estimates average daily hot water used.

There is a degree of uncertainty in estimating hot water use because of the limited data on measured actual hot water use. We estimate uncertainty attached to the weighting factors using normal distributions for parameters provided in the 1985 EPRI study. Based on the 1985 EPRI study, ''Electric Water Heating for Single-Family Residences: Group Load Research and Analysis,'' LBNL developed values for daily hot water used for the number and age of people living in the home and for the presence of appliances. (1996. LBNL–37805)

RECS provides data on the number and age of household occupants, presence of a clothes washer or dishwasher, and three ranges of water heater tank size: small, medium, and large. For this analysis, however, we needed specific water heater sizes. By matching the three RECS ranges (small, medium, and large) with the standard water heater sizes, we assigned an exact water heater size to each RECS house. Generally, small is equivalent to 30 gallons, medium to 40 gallons, and large to 50 gallons or larger.

3. Consumer Subgroup Analysis

In the Process Rule, DOE committed to considering the LCC impacts on consumer subgroups who might be uniquely affected by a rulemaking. Process Rule, Appendix A (11)(d). DOE used LCC as the metric to determine consumer impacts. See Chapter 10 in the TSD for consumer subgroup analysis.

The Consumer Subgroup Analysis for water heaters estimates the variation in energy consumption and LCC for different subgroups of consumers under different trial standard levels. Of particular interest is the potential effect of standards on households with low incomes and on seniors over 65. DOE identified these two subgroups from stakeholder input at the water heater workshop on November 11, 1998. The analysis answers questions such as: How many households of this type are better off with standards and by how much? How many households are worse off and by how much?

By comparing the LCC of all consumers to the LCC of the specific consumer subgroups referenced above, we determine if the standards will affect those subgroups differently. DOE made these determinations for each trial standard level for low income and seniors-only households.

AGA stated DOE must provide statistical support for the way the RECS data are used in the Consumer Subgroup Analysis. (AGA, No. 68 at 6). There are a total of 484 records for low income households and 779 records for senior-only households in the RECS database. Most of the low income or senior-only households have either a gas-fired or electric water heater. DOE used the RECS data because it is the most complete and largest database publicly available.

4. Payback Analysis for Rebuttable Presumption

The Act establishes a rebuttable presumption that a standard is economically justified if the additional product costs attributed to the standard are less than three times the value of the first year energy savings. Section 325(o)(2)(B)(iii), 42 U.S.C. 6295 (o)(2)(B)(iii).

The payback period measures the amount of time needed to recover the additional money the consumer invests in increased efficiency through lower operating costs. Numerically, the payback period is the ratio of the increase in purchase (and installation) price to the decrease in annual operating expenditures (including maintenance) from replacing the 2003 baseline water heater with a water heater incorporating another more efficient design option.

For purposes of the rebuttable presumption test, DOE identifies the design options with the highest efficiency that have a payback of no more than three years. Since the Act requires that the rebuttable presumption be based on the DOE test procedure, it is determined in the engineering analysis. See section IV.A.1.c. of this notice for these results.

F. National Impacts Analysis

1. Net Present Value (NPV) and Energy Savings

The national impacts analysis assesses the NPV of total consumer LCC and energy (and water, if appropriate) savings. A preliminary assessment of the aggregate impacts at the national level is conducted for the NOPR. Analyzing impacts of Federal energy-efficiency standards requires a comparison of projected U.S. residential energy consumption with and without standards. The base case, which is the projected U.S. residential energy consumption without standards, includes the mix of efficiencies being sold at the time the standard becomes effective. Sales projections together with efficiency levels of the water heaters sold, are important inputs to determine the total energy consumption due to water heaters under both base case and standards case scenarios. The differences between the base case and standards case provides the energy and cost savings. Depending on the analysis method used, the sales under a standards case projection may differ from those of a base case projection.

The Department estimates national energy and water, if applicable, consumption for each year beginning with the expected effective date of the standards. National annual energy and water savings are calculated as the difference between two projections: a base case and a standards case.

Analysis begins with estimated energy savings by fuel type for electricity, natural gas, LPG, and oil. DOE estimates energy consumption and savings based on ''site energy'' (kWh of electricity, million Btu of natural gas, LPG or oil used in the home). The Act defines ''energy use'' as the ''quantity of energy directly consumed by a consumer product at the point of use, determined in accordance with test procedures under Section 323.'' Section 321(4), 42 U.S.C. 6291(4). This is generally called ''site'' energy as opposed to ''source'' energy, which includes transportation and generation losses.

The energy savings to the nation are expressed in quadrillions of Btu's of ''source'' energy. The National Energy Savings (NES) spreadsheet model first calculates the energy savings in site energy, kWh or Btu, and then uses a time series of conversion factors to convert site energy to source energy. This was a recommendation by the Appliance Efficiency Advisory Committee that the Department implemented recently. The conversion factors are derived from the AEO99 (DOE/EIA–0383).

Measures of impact reported include the NPV of the energy savings in dollars and the energy savings at the source. Each of the above are determined for selected trial standard levels. These calculations are done by the use of a spreadsheet tool called the NES spreadsheet model, which has been developed for all the appliance standards rulemakings and tailored to each specific appliance rulemaking.

In the water heater rulemaking, the NES spreadsheet model also forecasts fuel type market shares to new housing completions. Fuel switching may be caused by price increases of gas-fired and/or electric water heaters due to standards or other government agency actions. DOE examines several scenarios in order to include the range of possibilities for different market shares of electric and gas-fired water heaters (see Chapter 11.3 of the TSD).

2. National Energy Savings (NES) Spreadsheet Model

Table 6 lists the major assumptions that DOE used in the water heater NES analysis. We discuss many of these assumptions briefly in this section. We discuss in more detail below our shipment analysis because shipments are an important input to the NES analysis. The shipment model predicts the number of water heaters expected to be sold each year between 2003 and 2030. For more details on the NES analysis, please see Chapter 12 in the TSD.

TABLE 6.—ASSUMPTIONS USED IN THE NATIONAL ENERGY SAVING ANALYSIS

National energy savings assumptions	
Description	Assumption
Real Discount Rate and Year of the NPV	7% discounted to the year 1998.
Start Year of New Standards	2003.
Energy Savings	Source Consumption.
Average Marginal Energy Price	From the LCC analysis adjusted to 1998$.
Average Retail Prices and Installation Costs	From the LCC analysis.
Energy Price Projections to 2020	AEO99.
Extrapolation of Energy Prices to 2030	For petroleum, we use the average world oil price with markups from 2020; for gas, we use the average growth rates from 1997–2020 with margins from 2020; electricity prices are constant at 2020 levels.
Electric Source to Site Conversion Factors	Time variant values from AEO99.
Gas Source to Site Conversion Factors	0.9 from AGA.
Voluntary Programs	Included in the base case via historical shipments data.
Annual Unit Energy Consumption	Values from the engineering analysis are market weighted by shipments forecasts.
Base Case	Electric: 80% low efficiency, 20% high efficiency. Gas-fired: 70% low efficiency, 12% medium efficiency, 18% high efficiency. Oil-fired: 80% low efficiency, 15% medium efficiency, 5% high efficiency.

The NES spreadsheet model determines the total source energy savings and the NPV of these savings. The model calculates net savings each year as the difference between total operating cost savings and total equipment cost increases. The NPV calculations also capture any differences in maintenance costs. NPV greater than zero indicates net savings (*i.e.*, that the standard reduces consumer expenditures in the standards case relative to the base case). NPV less than zero indicates that the standard incurs net costs. The elements of the NPV also can be expressed as a benefit/cost ratio. The benefit is the savings in decreased energy expense, while the cost is the increase in the purchase price due to standards relative to the base case. When the NPV is greater than zero, the benefit/cost ratio is greater than one and benefits exceed costs.

We determine equipment costs from the increased purchase price associated with the higher energy efficiency of appliances purchased in the standards case compared to the base case. We calculate equipment costs as the difference in the purchase price between the base case and trial standard levels for new water heaters purchased each year, multiplied by water heater sales. We accounted for the number of water heaters sold each year by tracking shipments of new water heaters and the average lifetime of each market share by trial standard levels. We determine the retail prices of the baseline design and the higher efficiency design options from the LCC Analysis. Purchase price includes the water heater installation cost.

Reductions in operating costs associated with the higher energy efficiency of water heaters purchased in the standards case—compared to the base case—create savings. Total operating cost savings are the product of savings per unit and the number of units of each age that continue to operate in a particular year. We accounted for the mix of different efficiencies each year using an average annual unit energy consumption weighted by the percentage of water heaters in the market.

DOE calculates national energy consumption for the base case and each trial standard level by multiplying the average energy consumption by water heater age times the number of water heaters of that age still in the stock. This yields an estimate of the national total energy consumption for a year. We calculated annual NES as the difference between the total energy consumption for the trial standard level and the base case. We summed the annual NES to obtain cumulative energy savings over the period 2003–2030. Then using energy conversion rates from the EIA's AEO99 or from AGA, we can calculate the source energy consumption and savings. Energy conversion rates account for generation and distribution losses of electricity and transportation and pumping losses of natural gas. DOE's proposed standard is only based on the AEO99 reference energy price forecasts, although we consider the high and low economic forecast.

NPV in a Saturated Market

NPV is the (discounted) difference in national water heater expenditures between the standard and base cases. Standards generally lower the average operating cost of appliances, but increase the average first (equipment) cost. Also, standards can cause consumers to make different purchase decisions, either choosing another product, *e.g.,* room air conditioner instead of central air conditioners, or another fuel type, *e.g.,* electric to gas. NPV accounts for these shifts.

Water heaters constitute a saturated market (96% of households)—standards are not expected to affect the percentage of households using a water heater. However, standards may affect the fuel type mixture of the water heater market. In calculating the NPV, the NES model accounts for two effects, the operating expenditures and increase in purchase price of the more efficient water heaters. The shipments model, an input to the NES, forecasts the change in market share of the various fuel types in response to the different standards. These shipment changes, due to purchase price, are reflected in the NES calculation of NPV.

Since trial standard levels 1 and 3 are the same for gas water heaters, one would expect the NPV for these two levels to be the same. The individual, or unit, change in purchase price and operating expenditures are the same for the two trial standards levels, however, the shipment model forecasts are different for gas and electric water heaters. These different shipment forecasts cause the aggregate equipment expenditures and operating costs to differ for the two trial standards levels.

Because of the higher cost of electric water heaters in trial standard level 3, the market share of electric water heaters is predicted to decrease. In the period between 2003 and 2030, the shipment model predicts about five million fewer electric water heater shipments in trial standard level 3 than in trial standard level 1. This loss in shipments of electric units is (roughly) compensated by an equivalent gain in gas unit shipments.

NPV, combined across fuel types, includes the effect of market share changes caused by standards. For a saturated market, which is the case with water heaters, this accounts for the effects on the nation of standards. Considering NPV separately by fuel type can be misleading because changes in shipments among fuel types (market effects due to price increases) can obscure the expected national energy savings due to improved efficiency across all product classes. For a complete discussion of this topic, see sections 12.2 and 12.5 of Chapter 12 in the TSD.

a. Shipments

One of the more important components of any estimate of future economic impact is shipments. Forecasts of shipments for the base case and the standard case need to be obtained as an input to the NES. Table 7 lists the major assumptions that DOE used in the water heater shipments analysis. We discuss many of these assumptions briefly in this section. For more details on the shipments analysis, please see Chapter 11 in the TSD.

TABLE 7.—ASSUMPTIONS USED IN THE SHIPMENTS ANALYSIS

Shipments analysis assumptions	
Description	Assumption
Base Case	Based on historic data and new housing starts, projected to 2030.
Existing Homes	Replace water heaters with units of the same fuel type. 96% of housing units have water heaters of the type analyzed here.
New Construction	Have a fuel choice, 96% of homes have a residential water heater of one of the four major fuel types. Number of housing units based on Census data and EIA forecasts.
Market Saturation in New Construction	Based on fuel price, equipment price and household income.
Implicit Discount Rates	Electric 191%, Gas-fired 83%, Oil-fired 124%, LPG 83%.
Cost Elasticities	From a 1979 Oak Ridge National Laboratory study, see Table 11.3 in the TSD.
Fuel Prices	AEO99 and GRI98.
Lifetime	Appliance Magazine 1998: Electric 4–19 yrs., most likely is 12 yrs; gas, oil and LPG, 3–15 yr., most likely is 9 yrs.

TABLE 7.—ASSUMPTIONS USED IN THE SHIPMENTS ANALYSIS—Continued

Shipments analysis assumptions	
Description	Assumption
Equipment Cost	From the LCC analysis.
Household Income	RECS93.

The Water Heater Shipments forecast spreadsheet is used primarily as an input into estimates of national impacts from standards implementation and into the manufacturer's impact analysis. The model predicts the total number of water heaters expected to be sold by manufacturers in each year between 2003 and 2030. In addition, it describes the change in fuel type market saturation due to implementing standards and other macroeconomic factors. The basic assumption of our analysis is that nearly all homes currently have a water heater with one of the four major fuel types, and that this trend will continue throughout the forecast period. Furthermore, we consider only water heaters serving a single housing unit. (We know from the RECS public use data that 4% of housing units built will either have no hot water, share a hot water heater with other units, or be fueled by a source other than the four fuel types, but we have excluded these from our analysis.)

In its comments, AGA asked why the consumer implicit discount rates are different for gas, electric, and oil. (AGA, No. 68 at 6). We use an implicit discount rate to model a consumer's behavior and the tendency to purchase the least expensive water heater. We assume consumers are strongly influenced by first cost and future savings are much less important. The implicit discount rates are different for each fuel class because they depend on the increase in consumer price from the baseline to the first design option. In the shipment analysis, we use the implicit discount rate to determine the value of future operating cost savings for gas-fired, electric, oil-fired and LPG water heaters.

ACEEE claimed DOE's analysis assumes purchasers are quite sensitive to operating costs and suggested DOE reduce the sensitivity to operating costs in the water heater shipment model similarly to the adjustments made to the clothes washer shipments model. (ACEEE, No. 93 at 5). We could not make any adjustments to our shipments model similar to the adjustments made for clothes washers because we do not have any consumer preference surveys for water heaters.

We use implicit discount rates to calculate equipment cost elasticities, which are about 2–5 times higher than operating cost elasticities. Based on the operating cost elasticities derived by the Oak Ridge National Laboratory (ORNL), we assume consumers are more sensitive to first cost than to operating cost. Using these calculations in the shipments model and the NES spreadsheet, we can assess the impact of fuel switching. The complete explanation and derivation of terms are in Chapter 11.3.2 of the TSD.

As part of its analysis to determine energy savings, the Department develops a base case forecast. The base case shipments is a forecast of annual shipments in the absence of new standards and their weighted average energy efficiency to the year 2030. This forecast requires an assessment of the impacts of past and current non-regulatory efforts by manufacturers, utilities and other interested parties. DOE considers information on the actual impacts of such initiatives to date, and also considers information presented regarding the possible impacts that any current initiatives might have in the future. Such information could include the actions manufacturers, distribution channels, utilities, or others will take to realize such voluntary efficiency improvements.

To develop a base case forecast of shipments, we used total water heater shipments from GAMA through 1993 and market share data from consultants to calibrate the model so it correctly estimates historical data. DOE calculated annual water heater shipments by fuel type as the sum of water heater installations in new housing and replacement units. We account for the energy saving impacts of non-regulatory efforts by manufacturers, utilities, and government (*e.g.*, the FEMP), in the base case and we forecast their effects in the future. DOE considered information on the actual impacts of such initiatives to date, and also considered information regarding possible impacts that any existing initiatives might have in the future. See Chapter 11.3.1 in the TSD for our estimates of the relative market share efficiencies for the base case.

Voluntary programs typically have a small but important effect in raising the future efficiency of the average appliance in the market. In the water heater market, utility programs and state building codes have created regional markets for high efficiency gas-fired and electric water heaters. See Section V.B of this notice for results of enhanced voluntary programs. FEMP also provides government purchasers with information about higher efficiency water heaters and their life-cycle costs. We included the effects of these programs in the base case by modeling the current market for each fuel type by efficiency level. DOE also is researching electric heat pump water heaters and hopes to increase their market penetration in the future by reducing the first cost to consumers. We have not included any impact from these efforts to increase heat pump water heater market penetration in our forecast since we are still doing research.

Since 1980, the U.S. has built about 1.3–2.1 million new housing units each year, including mobile home placements. From 1990–1993, about 96% of new housing units installed residential storage water heaters of the type and size considered under the standards. The remaining 4% of new housing units are not considered in the shipments forecast because the water heaters are shared among more than one housing unit or renewable energy sources are used for water heating. Thus, there are about 1.2–2.0 million residential storage water heaters installed in new housing each year. Since 1990, these installations have accounted for 15–20% of annual water heater shipments.

After accounting for new housing construction, the remaining 80–85% of shipments are replacements. We determined the number of replacements by using the number shipped in the past and a distribution of water heater life expectancies, which varies by fuel type.

The choice among competing fuels for water heating is highly correlated with the choice of fuel for space heating. Most homes use the same fuel for water heating as for space heating. In this analysis, we assume that when water heaters need to be replaced, they are replaced by water heaters of the same fuel type as the original; changes in market share occur primarily as a result of installation trends in new housing. Natural gas and electric water heaters account for the major shares of shipments. As of 1997, electric water heaters account for about 47%, and natural gas (including LPG) water heaters account for almost 53%. Sales of oil-fired water heaters account for less than 1% of water heater shipments.

DOE estimates shipments based on two markets: new housing construction and water heater replacements in existing housing. We assume replacements in existing housing equal retirements; that is, everyone replaces his or her worn-out water heater. We further assume consumers replace their water heaters with the same fuel type; that is, we assume no fuel switching in the replacement market. For each fuel type, the number of retirements is equal to the total stock of each vintage, multiplied by a retirement probability for that vintage contained in the lifetime function for that fuel type. Electric water heaters have a life expectancy of 4–19 years and gas-fired water heaters last from 3–15 years, with average lifetimes of 12 and 9 years, respectively, as published in the September 1998 issue of Appliance Magazine. We expect water heater replacements to constitute 85 percent of total water heater shipments by 2003. Total retirements calculated in this way show rough agreement with historical shipment data provided by GAMA, during the period from 1967 to the present.

The remainder of shipments comes from new housing construction. We took housing completions, including mobile home shipments, from census historic data and EIA forecasts. Currently, 96% of new homes generate a shipment of a water heater that is not shared and that is fired by one of the four major fuel types. We assume this percentage remains constant throughout the forecast period.

The projected shipments for each fuel type consist of the water heaters retired and replaced, plus the number of new homes multiplied by the new-home market saturation of the fuel type. Total modeled shipments agree with actual shipment data from 1980–1997.

In its comments, Battelle requested an explanation for the sudden shifts in shipments among fuel types in the analysis. (Battelle, No. 83 at 7). Although there may be shifts in shipments among fuel types, we expect the total number of water heaters shipped to, and installed in, consumers' homes (shipments) to be nearly the same under different trial standard levels. When standards become effective, all the baseline water heaters immediately have improved efficiency and higher prices. The change in price among fuel types causes the sudden shift in shipments.

EEI claimed the water heater shipment forecast seemed to be optimistic, with sales increasing for gas-fired and electric units every year from 2000–2030 (30 years). Past history has shown periods of flat or declining shipments. (EEI, No. 39 at 9). Our shipment forecast reflects the EIA's forecast of continued strong demand for new housing construction. Shipments of each fuel type may differ slightly, due to changes in market saturation occurring as a result of installation trends in new housing.

Fuel Switching and Market Share. The Department decided to study the potential impacts of different trial standard levels on fuel type market share using the shipment model. A large shift from one fuel to another may affect consumer costs and national energy consumption and environmental impacts. We created an Ad Hoc Water Heater Fuel Switching Working Group to assist us in investigating fuel switching concerns. The Working Group was made up of representatives from GAMA, gas and electric utilities and energy advocates. The Working Group decided that since most water heater replacements are usually emergencies, water heaters are always replaced with the same fuel type. Therefore, in our analysis we assume no fuel switching in the replacement market; all shifts in fuel type market share are assumed to occur in new construction.

The Department determined fuel type market share in new construction in response to economic conditions. The three components contributing to the type of water heater a consumer will buy are: equipment (initial) cost, operating (fuel) expense, and household income. The shipment model that we used takes income and fuel price projections through 2030 from EIA. Equipment costs and unit energy consumption are those calculated in the Engineering and LCC analyses. Each of these variables is related to consumer behavior by a set of cost elasticities from a 1978 study by the ORNL (ORNL/CON–24 1978). For more details on shipments and fuel switching, see Chapter 11.3 in the TSD.

Water heater market shares in new construction by fuel type in 1992 were: 47% electric; 44% natural gas; 1% oil; and 4% LPG. The shipments model shows a drop in gas market shares in the 1990s that may not be supported by data. Data from the American Housing Survey on space heating fuel market saturations shows no decline in gas heating fuel installations during the 1990s. Since space heating fuel and water heating fuels are highly correlated in households, we decided to conduct a sensitivity analysis to understand the impact of different shipment scenarios. We investigated several alternative scenarios based on constant market share. This scenario fits the results of the American Housing Survey. U.S. Census Bureau, Current Housing Reports, Series H150/97, September 1999.

We conducted the NES analysis to determine energy savings and NPV using a constant market shipment scenario and two scenarios based on a 10% change in the constant market shipments. Note that a constant market shipment fixes fuel shares so there is no fuel switching. For each of these scenarios, we forecast all four trial standard levels. In all cases, we held market shares of shipments constant throughout the forecast period. In the first scenario, we held market shares of shipments at 1992 values; that is, electric 47% and natural gas 44%. In the second scenario, we shift market shares of shipments 10%, to electric 57% and natural gas 34%. In the third scenario, we shift market shares of shipments to 37% electric and 54% natural gas.

Results from the NES analysis show only slight differences in NES among the three scenarios 0.06–0.11 quads compared to the model result of 4.75 quads. Among the three scenarios, NPV is at its highest level at trial standard level three although it is about 15% lower than the model forecast. Since we only changed the shipment model in the three scenarios and our shipment forecast falls within the range of the scenarios, we conclude the energy savings and economic benefits to consumers are not sensitive to a 10% increase or decrease in new construction market share of electric or gas-fired water heaters. Therefore, we have continued to use the model results in our analysis. We present the results for the sensitivity analysis in Chapter 11.3.3 of the TSD.

b. Energy Prices

Because the AEO99 forecasts only to the year 2020 while other analyses related to appliance energy efficiency are forecast to 2030, we extrapolated energy price data to 2030 using a method similar to the one that EIA uses to forecast fuel prices for FEMP. To determine the regional price forecasts for petroleum products, we used the average growth rate for the world oil price in combination with refinery and distribution markups from 2020.

Similarly, we derived natural gas prices from the average growth rate over the years 1997–2020 in combination with regional price margins from the year 2020. We kept electricity prices constant at 2020 levels because we assume the transition to a restructured utility industry will be completed by then.

3. Comments

LaClede stated the spreadsheet only allows the EIA price, heat rate, emissions, and economic forecasts. (LaClede, No. 69 at 4). EMPA stated DOE's analyses appear to be biased toward EIA's high economic scenario. (EMPA, No. 88 at 2). The EIA high and low economic forecasts bound the GRI and AGA forecasts, with one exception. From 2016–2020, the EIA low growth scenario forecasts fuel prices that are higher than the GRI forecast. See Appendix E–4 of the TSD for the results of alternate energy price forecasts. The spreadsheets can produce output based on any of the four economic scenarios. We based our decision on the reference case in the AEO99 energy price forecasts. This is the middle range of the energy price forecast and there is no bias toward the high economic scenario.

AGA commented that the national energy analysis spreadsheet does not permit alternative inputs for electricity generation efficiency. (AGA, No. 68 at 4). The NES spreadsheet models include a clearly defined column of conversion factors, one for each year of the projection. DOE and stakeholders can examine the effects of alternative assumptions by substituting different values in this column.

The model calculates national energy consumption at the site (*i.e.*, electricity in kWh, natural gas, LPG, and oil in MMBtu, consumed in the household). Based on this site energy consumption, DOE applied site-to-source conversion factors to calculate the primary energy consumed. The conversion factors are different for natural gas and electricity and account for losses, such as losses in generation, transmission, and distribution of electricity, or distribution losses for natural gas. This analysis assumes that the source conversion factor changes over time, and applies annual values. The model uses the U.S. annual electricity conversion factors from AEO99, Table A4 (DOE/EIA 1998). The source conversion factor applied to site natural gas consumption is the site energy divided by 0.9 (Natural Gas Council (NGC), 1998).

In comments on the November 1998 analysis, AGA claimed the gas source-to-site conversion should be 90%, but the spreadsheet for the July workshop used 78% in 2003 and 81% in 2030. (AGA, No. 68 at 4). We have corrected this error in the baseline case of the NES spreadsheet and the conversion is now 90%. However, for the natural gas savings from the trial standard levels we use a marginal site to source gas conversion factor from NEMS–BRS model (see Section III.I of this notice) that is approximately 91%. See Chapter 12 of the TSD.

NGC stated that in the case of natural gas, approximately 10% of the total energy is lost in the journey from the wellhead to the burner tip. NGC compared this loss to losses of 73% for electricity generation and distribution. It claims a total energy efficiency analysis will show gas-fired water heaters to be more efficient and cost effective than their electric counterparts. (NGC, No. 59 at 1).

The Department has always believed that, in evaluating the impacts of appliance standards, one must consider the full range of impacts, including consumer and national impacts. In the analysis of consumer impacts, the Department considers the energy directly consumed by the product at the point of use. The measures of energy efficiency and energy use are, for example, all based on the energy consumed at the point of use and these are the measures of energy use that are used in the consumer analyses, *e.g.*, LCC in Section III.E of this notice. See Section 321(4) of EPCA, as amended, 42 U.S.C. 6291(4), which defines energy use in this manner. This, DOE believes, provides useful measures to consumers since it can be directly related to information readily available, *i.e.*, utility bills. In examining the impacts of standards on the nation, however, the Department considers the total energy consumed over the entire fuel cycle as well as emissions and energy costs. In this manner, the analysis captures the total impact of the standards.

G. Manufacturer Impact Analysis

1. Economic Impact on Manufacturers

The economic impact of the standard on manufacturers is a criterion that must be considered under EPCA, as amended. Section 325(o)(2)(B)(i), 42 U.S.C. 6295(o)(2)(B)(i). The Process Rule provides guidance on how to assess these potential impacts on manufacturers. 10 CFR 430, subpart C, appendix A 10. First, the Department will utilize an annual cash flow approach in determining the quantitative impacts on manufacturers. This includes a short-term assessment based on the cost and capital requirements during the period between the announcement of a regulation and the time when the regulation comes into effect. We will examine critical variables affecting manufacturers, such as industry NPV, cash flows by year, changes in revenue and income, changes in product price as it affects the fuel type of water heaters shipped, and other variables, as appropriate. Second, the Department will analyze and report the impacts on different types of manufacturers, with particular attention to impacts on small manufacturers. Third, the Department will consider the impact of standards on domestic manufacturer employment, manufacturing capacity, plant closures and loss of capital investment. Finally, the Department will consider the cumulative impacts of other DOE and other Federal agencies' regulations on manufacturers.

2. Product Specific

The manufacturing impact analysis (MIA) estimates the financial impact of standards on manufacturers, as well as the impacts on competition, employment, and manufacturing capacity. Table 8 lists the major assumptions that DOE used in the water heater MIA. We discuss each of these assumptions briefly in this section. For more details on the MIA, please see Chapter 13 in the TSD.

TABLE 8.—ASSUMPTIONS USED IN THE MANUFACTURING IMPACT ANALYSIS (MIA)

Assumptions in the manufacturer impact analysis	
Description	Assumption
Manufacturer Costs and Investments	GAMA & consultants' estimates.
Financial Information	SEC–10K Reports, Moody's Company Data Reports, Standard & Poor's Stock Reports, and Robert Morris Associates Reports.
Shipments	From the shipments forecast.

TABLE 8.—ASSUMPTIONS USED IN THE MANUFACTURING IMPACT ANALYSIS (MIA)—Continued

Assumptions in the manufacturer impact analysis	
Description	Assumption
Business Scenarios	1. Full recovery of investment, 2. Loss of all investment, 3. Recovery of 75% of investment.
Other Federal Regulatory Actions	Phase out of HCFC–141b on January 1, 2003 and the CPSC initiative to prevent ignition of flammable vapors on gas-fired water heaters.
Qualitative Impacts	From interviews.

We conducted the MIA in three phases. Phase one consisted of the preparation of an industry characterization as well as individual meetings with manufacturers to identify issues facing the water heater industry. Phase two focused on the larger industry. In this phase, DOE used the Government Regulatory Impact Model (GRIM) to perform an industry cash flow analysis. Phase three entailed documenting additional impacts on competition, employment, and manufacturing capacity based on comments during the manufacturer's interviews. Below, we describe the three analytical tools used to accomplish these three phases: GRIM modeling, manufacturer subgroup analysis, and interviews.

There are two other government regulatory actions that water heater manufacturers must incorporate into their manufacturing process by January 1, 2003, or sooner. First, the EPA phase out of HCFC's will require an alternative insulation blowing agent. Second, the CPSC initiative to prevent ignition of flammable vapors on gas-fired water heaters will require design, development, testing and production of a radically new gas burner. We account for these two actions in the MIA as cumulative effects along with energy efficiency standards.

3. GRIM: Industry Cash Flow

A change in energy efficiency standards affects manufacturers in three distinct ways. More stringent standards require additional investment, raise production costs, and affect revenue through higher prices and, possibly, lower quantities sold. To quantify these changes, the Department performed an industry cash flow analysis using the GRIM. The GRIM analysis uses a number of factors—annual expected revenues, manufacturer cost of sales, selling and general administration costs, taxes, and capital expenditures related to depreciation, new standards, and maintenance—to arrive at a series of annual cash flows beginning before implementation of standards and continuing explicitly for several years after implementation. DOE obtained financial information, also required as an input to GRIM, from publicly available data and aggregated values of confidentially submitted manufacturer information. Discounted annual cash flows from the period before implementation of standards to some future point in time provide the measure of industry net present values.

Given the relatively small number of firms in the industry, the Department created an industry cash flow analysis using a combination of top-down and bottom-up approaches. In order to facilitate individual manufacturer analyses, the Department prepared baseline scenarios for a ''strawman'' manufacturer using publicly available financial information (top-down). Manufacturers were able to modify relevant parameters to meet their own situation (price, cost, financial, etc.) (bottom-up). DOE aggregated the modified inputs to the GRIM to develop an industry cash flow. DOE then used this industry cash flow to determine the economic burden on manufacturers for energy efficiency standards as well as other regulations currently facing the industry.

The Department received manufacturing cost data for the various design options for typically-sized gas-fired and electric water heaters from manufacturers; GAMA had compiled and reported these data. DOE consultants provided manufacturer costs for the various design options for typically-sized oil-fired water heaters. DOE used the initial GAMA data, coupled with publicly available financial information, to develop a ''strawman'' industry cash flow.

In preparing the industry cash flow analysis, the Department used the same shipment scenarios in the GRIM and the NES spreadsheets. The other GRIM inputs are firm-level financial information that indicates the extent to which individual firms may be adversely impacted by new standards. To obtain estimates for these inputs we analyzed publicly available, firm-specific financial information—SEC–10K Reports, Moody's Company Data Reports, Standard & Poor's Stock Reports, and Robert Morris Associates Reports—for major water heater manufacturers.

4. Manufacturer Subgroup Analysis

Using industry ''average'' cost values is not adequate for assessing the variation in impacts among subgroups of manufacturers. Standards could more negatively affect smaller manufacturers, niche players, or manufacturers exhibiting a cost structure largely different from industry averages. The Department conducted detailed interviews with as many manufacturers as possible to gain insight into the potential impacts of standards. During these interviews, the Department solicited the information necessary to evaluate cash flows and to assess competitive, employment, and capacity impacts. The Department also considered firm-specific cumulative burden. We requested participation from both large and small manufacturers, but only four of the five large manufacturers responded. No small manufacturers responded to DOE's request for interviews, so examination of the small manufacturers was not possible at the quantitative level carried out for the large manufacturers.

5. Interview Process

The interview process played a key role in the MIA, because it provided an opportunity for interested parties to privately express their views on important issues. A key characteristic of the interview process is that it allows DOE to consider confidential information in its decision making process.

The Department developed a detailed and focused questionnaire, using information collected during the industry characterization process from industry and market publications, industry trade organizations, company financial reports, and product literature. The Department of Justice (DOJ) reviewed and commented on the interview questionnaire. The interview questionnaire solicited information on the possible impacts of trial standard levels on manufacturing costs, product prices, and sales. The questionnaire solicited both qualitative and quantitative information. Evaluation of the possible impacts on direct employment, capital assets, and industry competitiveness drew heavily on the information gathered during the interviews.

The questions on competitive impacts pertained to the assessment of the likelihood of increases in market concentration levels and other market conditions that could lead to anti-competitive pricing behavior. The manufacturer interviews also gathered information that helped in assessing whether there may be asymmetrical cost increases to some manufacturers, whether any increased proportion of fixed costs potentially increases business risks, and whether there are any potential barriers to market entry (*e.g.,* proprietary technologies).

DOE conducted face-to-face interviews with four of the five major water heater manufacturers in the winter and spring of 1999. During these interviews, the Department solicited the information necessary to evaluate cash flows and to assess competitive, employment, and capacity impacts. DOE also discussed firm-specific cumulative regulatory burdens. DOE has not placed any confidential information from the manufacturer interviews in the public record. However, DOE considered all of the information collected by interviews in its decision making process.

DOE collated the completed interview questionnaires and prepared a summary. Chapter 13.3.2 of the TSD discusses the major issues identified by the manufacturers during the interview process. Also, Appendix H–1 of the TSD contains a copy of the manufacturer's interview guide.

The manufacturer interviews allowed a free exchange of information between DOE representatives and manufacturer representatives, in a manner that does not occur in public meetings. From this exchange, the Department gained much more than quantitative data on the financial impacts of the trial standard levels for each particular company. During the interviews, DOE and manufacturers discussed rulemaking issues such as:

—The requirements for a new blowing agent,
—Design options that are particularly costly or difficult to manufacture or market,
—Marketing and distribution issues,
—Impacts of developing and manufacturing gas-fired water heaters that prevent ignition of flammable vapors, and
—Installation concerns due to thicker insulation.

H. Other Factors

This provision allows the Secretary of Energy, in determining whether a standard is economically justified, to consider any other factors that the Secretary deems to be relevant. Section 325(o)(2)(B)(i)(VI), 42 U.S.C. 6295(o)(2)(B)(i)(VI). The Secretary has decided that no other factors need to be considered in this rulemaking.

I. Utility Analysis

The utility analysis estimates the effects of the reduced energy consumption due to improved appliance efficiency on the utility industry. Because electric utility restructuring is well underway, it is no longer valid to assume a cost recovery mechanism under public utility regulation, which was the basis of previous utility impact analyses. Therefore, this utility analysis consists of a comparison between forecast results for a case comparable to the AEO99 Reference Case and forecasts for policy cases incorporating each of the water heater trial standard levels.

Table 9 lists the major assumptions DOE used in the water heater utility analysis. We discuss each of these assumptions briefly in this section. For more details on the utility analysis, please see Chapter 14 in the TSD.

TABLE 9.—ASSUMPTIONS USED IN THE UTILITY IMPACT ANALYSIS

Utility impact analysis assumptions	
Description	Assumption
Energy Prices	AEO99.
Energy Savings	From the NES spreadsheet as site energy savings.
Interpolation of Scaling Factors	Linear.

The Department uses a variant of EIA's widely recognized National Energy Modeling System-Building Research and Standards called NEMS–BRS for the utility analysis, together with some scaling and interpolation calculations.[1] EIA uses NEMS primarily for the purpose of preparing the Annual Energy Outlook. Using NEMS, EIA produces a baseline forecast for the U.S. energy economy through 2020. The NEMS–BRS model used for this analysis is based on the AEO99 version of NEMS with minor modifications.

NEMS–BRS has several advantages that have led to its adoption as the source for basic forecasting in the appliance energy efficiency analyses. NEMS–BRS relies on the AEO99 assumptions, which are well-known and accepted due to the exposure and scrutiny each AEO receives. In addition, the comprehensiveness of NEMS–BRS permits the modeling of interactions among the various energy supply and demand sectors and the economy as a whole, so it produces a sophisticated picture of the effects of appliance standards. Perhaps most importantly, because it explicitly simulates the impact on the industry, NEMS–BRS provides an accurate estimate of marginal effects, which yield better indicators of actual effects than estimates based on industry-wide average values. Marginal rates show only the effects of standards. Average rates show the effects of standards as well as what is happening in the market.

To analyze the effects of standards, we evaluate the trial standard levels by entering the changes in electricity, gas, LPG, and oil consumption values into the NEMS–BRS Residential Demand Module. We took the energy savings input from the NES spreadsheet, applied it to the water heater end use, and allocated it appropriately among census divisions. In the TSD, we report

[1] For more information on NEMS, please refer to the National Energy Modeling System: An Overview 1998. DOE/EIA–0581 (98), February, 1998. DOE/EIA approves use of the name NEMS to describe only an official version of the model without any modification to code or data. Because our analysis entails some minor code modifications and the model is run under various policy scenarios that are variations on DOE/EIA assumptions, the name NEMS–BRS refers to the model as used here. BRS is DOE's Building Research and Standards office.

results for several key industry parameters, notably residential energy sales, generation, and installed capacity, including the fuel mix that is used for generation. See Chapter 14 of the TSD for more details.

J. Environmental Analysis

The Department determines the environmental impacts of each standard level as required in Section 325(o)(2)(B)(i)(VI), 42 U.S.C. 6295(o)(2)(B)(i)(VI). Specifically, DOE calculates the reduction in carbon dioxide (CO_2, nitrous oxide (NO_x) and sulfur dioxide (SO_2) emissions with the NEMS–BRS computer model, together with some external calculations. NEMS–BRS is a modification of the National Energy Modeling System used by DOE/EIA.

Table 10 lists the major assumptions DOE used in the water heater environmental analysis. We discuss each of these assumptions briefly in this section. For more details on the environmental analysis, please see Chapter 14 in the TSD.

TABLE 10.—ASSUMPTIONS USED IN THE ENVIRONMENTAL ANALYSIS

Environmental analysis assumptions	
Description	Assumption
Energy Prices	AEO99.
Energy Savings	From the NES spreadsheet as site energy savings.
Interpolation of Scaling Factors	Linear
Household Emissions	CO_2, NO_X & SO_2 estimated from general factors.

We analyze the environmental effects of proposed water heater energy-efficiency standards using NEMS–BRS plus some scaling and interpolation calculations. Inputs to NEMS–BRS are similar to those used for the AEO99 reference case, except residential energy usage for water heaters is reduced by the amount of energy (gas, oil, LPG, and electricity) saved due to the water heater trial standard levels.

The environmental analysis considers two pollutants, SO_2 and NO_X, and one emission, CO_2. NEMS–BRS has an algorithm for estimating NO_X emissions from power generation. Since we use the AEO99 version of NEMS, the May 25, 1999 EPA rule (64 FR 28249) on trading of NO_X is fully incorporated in our analysis. However, NEMS–BRS estimates of NO_X emissions are incomplete because NEMS–BRS does not estimate household emissions. Household emissions result from the combustion of fossil fuels, primarily natural gas, within individual homes. Because households that use natural gas, fuel oil, or LPG contribute to NO_X emissions, DOE's analysis includes a separate household NOx emissions estimation, based on simple emissions factors derived from the general literature. NEMS–BRS tracks CO_2 emissions based on the total of fuels consumed. NEMS–BRS also produces comprehensive estimates of the benefits of the trial standard levels, so no additional analysis is necessary. Because SO_2 emissions from power plants are capped by clean air legislation, physical emissions of this pollutant from electricity generation will be only minimally affected by possible water heater standards. Therefore, we do not consider power plant SO_2 emissions here, although we report household emissions savings using a method similar to that described for NO_X. See Appendix EA–1 in the TSD for the methodology used to derive emission factors for residential combustion.

The NES spreadsheet provides the input of energy savings for NEMS–BRS, which then produces the emissions forecast. We calculate the net benefits of the standard as the difference between emissions estimated by the reference case version of NEMS–BRS and the emissions estimated with the trial water heater standard in place. See the Environmental Assessment (EA) bound into the TSD for details.

We received several comments from stakeholders about the environmental analysis in NEMS–BRS. SC commented that the EIA treats electricity from renewable sources the same as fossil-fired generation. SC believes there is no benefit to ''saving'' hydroelectric, wind, geothermal generation, or biomass Btus. (SC, No. 42 at 3). However, DOE believes there are benefits from end-use electricity savings. Usually end-use savings result in differences in fossil fuel generation and not the fuels listed by SC because fossil fuels tend to be displaced first. The emissions reductions reported in this rulemaking are the net result of changes in the mix of electricity generating fuels used. Changes in equipment and any construction program adjustments that result from proposed standards are also accounted for. For example, DOE will only record CO_2 emissions savings to the extent that electricity generators burn less fuels emitting CO_2.

LaClede commented that DOE's emissions models appear to severely underestimate electric losses from extraction to generation, whereas natural gas losses are accounted for from the point of extraction to the point of end-use. (LaClede, No. 47 at 2). All losses from natural gas production are accounted for in NEMS–BRS. NES estimates are inputs to NEMS–BRS. They affect the natural gas supply system and are therefore completely accounted for in the model. As reductions in end-use consumption result in less natural gas generation, less gas is extracted from wellheads resulting in less transportation losses from point of extraction through pipelines.

NEMS–BRS accounts for total CO_2 emissions, so the full fuel cycle of carbon is incorporated from both coal and natural gas production. However, since NO_X and SO_2 emissions are only treated in the power sector, emissions of these pollutants caused by mining and transporting fuel for power plants (''upstream emissions'') are ignored in NEMS–BRS. For electric end-uses, all energy losses associated with transmission and distribution from electric generators to residential appliances are included. Appendix EA–2 was included in the TSD to quantify the relative contribution of these upstream emissions to those reported in NEMS-BRS. DOE does not include the estimates of upstream coal mining emissions in its emissions reduction estimates.

VP commented DOE should use marginal electric generating plant emission rates in the analysis to be more accurate and consistent with the energy costs. (VP, No. 45 at 3). Reported emissions are calculated from marginally displaced electric generation as simulated in NEMS–BRS.

K. Net National Employment

The Process Rule includes national employment impacts among the factors

DOE considers in selecting a proposed standard; 10 CFR 430 subpart C, appendix A(4)(d)(7)(vi). The Department estimates the impacts of standards on employment for appliance manufacturers, relevant service industries, energy suppliers, and the economy in general. We estimate two employment impacts: total and direct impacts. Total impacts—or net national employment impacts—are impacts on the national economy, including the manufacturing sector being regulated. Direct employment impacts would result if standards led to a change in the number of employees at manufacturing plants and related supply and service firms. The MIA only discusses the direct employment impacts.

We define net national employment impacts from water heater standards as net jobs created or eliminated in the general economy. We expect the proposed energy efficiency standards for water heaters to save consumers money, although these savings will be partially offset by increased costs for water heaters. The resulting net savings are expected to be redirected to other forms of economic activity. We expect these shifts in spending and economic activity to affect the demand for labor, but there is no generally accepted method for estimating these effects.

One method to assess the possible effects on the demand for labor of such shifts in economic activity is to compare sectoral employment statistics developed by the Labor Department's Bureau of Labor Statistics (BLS). The BLS regularly publishes its estimates of the number of jobs per million dollars of economic activity in different sectors of the economy, as well as the jobs created elsewhere in the economy by this same economic activity. BLS data indicates that expenditures in the electric sector generally create fewer jobs (both directly and indirectly) than expenditures in other sectors of the economy. There are many reasons for these differences, including the capital-intensity of the utility sector and wage differences. Based on the BLS data alone, we believe net national employment will increase due to shifts in economic activity resulting from the water heater standards.

In developing this proposed rule, the Department attempted a more precise analysis of national employment impacts using an input/output model of the U.S. economy. The model characterizes the interconnections among 35 economic sectors using the data from the Bureau of Labor Statistics. Since the electric utility sector is more capital-intensive and less labor-intensive than other sectors (see Bureau of Economic Analysis, Regional Multipliers: A User Handbook for the Regional Input-Output Modeling System (RIMS II), Washington, DC, U.S. Department of Commerce, 1992), a shift in spending away from energy bills into other sectors would be expected to increase overall employment. For more details on the net national employment analysis, please see Chapter 15 in the TSD. This analysis also concluded that the shifts in sectoral expenditures likely to result from the proposed ballast standard would likely increase the net national demand for labor.

Because this is a new analysis for an energy conservation standard rulemaking, we are requesting public comments on the validity of the analytical methods used and the appropriate interpretation and use of the results of this analysis.

IV. Analytical Results

A. Trial Standard Levels

Based on the combination of design options that represent the most energy efficient level and the results of the LCC, MIA and NES analyses, we selected the following trial standard levels (see Table 12). In selecting trial standard levels, we followed the guidance set forth in the Process Rule, 10 CFR 430, Subpart C, Appendix A, 5(c)(3), to identify and select candidate standard levels at the lowest LCC, a three year or less payback period, and the most energy efficient combination of design options.

We have established four trial standard levels. Each level is made up of a combination of design options for each of the three fuel classes (electric, gas and oil). Several of the trial standard levels have the same efficiency within a particular fuel type (*i.e.,* gas-fired trial standard level one and three have the same efficiency, but the electric and oil-fired efficiencies are different). This allows us to evaluate different design option combinations of fuel classes for subsequent analysis, permitting us to make an informed decision on the merits of different trial standard levels. We repeated some energy efficient, cost effective design options for electric and gas-fired water heaters in the selected trial standard levels to reduce the potential for fuel switching between these fuels. Table 11 presents the baseline and trial standard levels and associated design options for each fuel class of water heater.

TABLE 11.—TRIAL STANDARD LEVELS FOR WATER HEATERS WITH HFC–245FA BLOWING AGENT

Trial standard level	Design options	Energy factor
Basecase	Electric: Baseline	.93—.00132V*
	Gas: Baseline	.62—.0019V
	Oil: Baseline	.59—.0019V
1	Electric: Heat Traps + Tank Bottom Insulation	.95—.00132V
	Gas: Heat Traps + Flue Baffles (78% RE) + 2 Inch Insulation	.67–.0019V
	Oil: Heat Traps	.60—.0019V
2	Electric: Heat Traps + Tank Bottom Insulation + 2 Inch Insulation	.96–.00132V
	Gas: Heat Traps + Flue Baffles (78% RE) + 2.5 Inch Insulation	.68—.0019V
	Oil: Heat Traps	.60–.0019V
3	Electric: Heat Traps + Tank Bottom Insulation + 2.5 Inch Insulation	.97—.00132V
	Gas: Heat Traps + Flue Baffles (78% RE) + 2 Inch Insulation	.67—.0019V
	Oil: Baseline	.59—.0019V
4	Electric: Heat Traps + 3 Inch Insulation + Plastic Tank	.98—.00132V
	Gas: Heat Traps + Flue Baffles (80% RE) + 3 Inch Insulation + Side Arm Heater +Plastic Tank + IID	.79—.0019V
	Oil: Heat Traps + 3 Inch Insulation + Interrupted Ignition + Increased Heat Exchanger Area (82% RE)	.67—.0019V

* V is the Rated Storage Volume, which equals the water storage capacity of a water heater, in gallons, as specified by the manufacturer.

Based on Honeywell's September 13, 1999, public announcement that it will produce HFC–245fa, the proposed standard levels are based on insulation blown with HFC–245fa. We considered insulation thicknesses of 2 inches, 2.5 inches, and 3 inches. Although we do not report the results of the water blown insulation analyses here, we completed a full analysis using water blown foam for each trial standard level. We chose HFC–245fa over water blown insulation because of 0.7 to 1.7 quads more energy savings for trial standard levels one to four. We request comments on the use of water blown insulation since DOE has analyzed both options. Results from the water blown insulation analyses are found in the TSD. Chapter 9.7 in the TSD has tables for HFC–245fa and water-blown insulation and the associated design options for each fuel class of water heater.

Water heater energy conservation standards vary as a function of the water heater volume. Section 325(e) of EPCA as amended, 42 U.S.C. 6295(e). DOE defines this volume as the rated volume based on manufacturers' labeling. See 10 CFR 430, subpart B, appendix E. For this rulemaking, DOE verified that these volumetric coefficients were consistent for the increased levels of efficiency under consideration in the analysis.

1. Economic Impacts on Consumers

a. Life-Cycle-Cost

To evaluate the economic impact on consumers, we conducted a LCC analysis for each of the fuel types and trial standard levels including estimating the percent of the population that benefits at each trial standard level. Table 12 shows the average LCC savings and percent of households benefitting for each of the trial standard levels for each of the fuel classes. The average LCC savings for trial standard levels one, two and three are positive for gas-fired and electric water heaters with the HFC–245fa blowing agent. Only trial standard level three is not negative for oil-fired water heaters, and it is the baseline. None of the other trial standard levels has positive average LCC savings for oil-fired water heaters because energy savings are small compared to the increase in consumer price.

Where LCC savings are positive for electric and gas-fired water heaters, the percent of households benefitting ranges from 74–91% for the trial standard levels analyzed. For oil-fired water heaters, the maximum of households benefitting is 25% at trial standard level two. However, even at trial standard level four, 20–31% of households with electric or gas-fired water heaters will benefit.

TABLE 12.—LIFE-CYCLE-COST SAVINGS AND PERCENT BENEFITTING

[HFC–245fa Blown Insulation]

Trial standard level	Design options	Percent benefitting	Life-cycle cost savings
1	Electric: Heat Traps + Tank Bottom Insulation	91	32
	Gas Heat Traps + Flue Baffles (78% RE) + 2 Inch Insulation	87	43
	Oil: Heat Traps	25	−15
2	Electric: Heat Traps + Tank Bottom Insulation + 2 Inch Insulation	79	36
	Gas: Heat Traps + Flue Baffles (78% RE) + 2.5 Inch Insulation	79	34
	Oil: Heat Traps	25	−15
3	Electric: Heat Traps + Tank Bottom Insulation + 2.5 Inch Insulation	74	40
	Gas: Heat Traps + Flue Baffles (78% RE) + 2 Inch Insulation	87	43
	Oil: Baseline	NA	0
4	Electric: Heat Traps + 3 Inch Insulation + Plastic Tank	31	−55
	Gas: Heat Traps + Flue Baffles (80% RE) + 3 Inch Insulation + Side Arm Heater + Plastic Tank + IID.	20	−214
	Oil: Heat Traps + 3 Inch Insulation + Interrupted Ignition + Increased Heat Exchanger Area (82% RE).	0	−459

Another LCC analysis we conducted is the Consumer Subgroup analysis. This analysis examines the economic impacts on different groups of consumers by estimating the average change in LCC and by calculating the fraction of households that would benefit. We analyzed the potential effect of standards for households with low income levels and senior-only households, two consumer subgroups of interest identified by DOE and supported by stakeholders. We present the results of the analysis in Table 13.

TABLE 13.—CONSUMER SUBGROUP LCC SAVINGS AND PERCENT OF HOUSEHOLDS BENEFITTING

Trial std levels	Sample households benefitting (%)			Average LCC Savings ($)		
	Total	Senior-only	Low income	Total	Senior-only	Low income
Electric Water Heaters, HFC–245fa blown insulation						
1	91	94	92	32	34	29
2	79	83	80	36	48	43
3	74	77	76	40	53	48
4	31	34	28	−55	−46	−66
Gas-fired Water Heaters, HFC–245fa blown insulation						
1	87	90	91	43	42	46
2	79	80	82	34	34	38
3	87	90	91	43	42	46
4	20	20	19	−214	−193	−206

TABLE 13.—CONSUMER SUBGROUP LCC SAVINGS AND PERCENT OF HOUSEHOLDS BENEFITTING—Continued

Trial std levels	Sample households benefitting (%)			Average LCC Savings ($)		
	Total	Senior-only	Low income	Total	Senior-only	Low income
Oil-Fired Water Heaters, HFC–245fa blown insulation						
1	25	20	25	−15	−11	−6
2	25	20	25	−15	−11	−6
3	0	0	0	0	0	0
4	0	0	0	−459	−512	−461

The two consumer subgroups show the same trend in average LCC savings and percent of sample households benefitting as the total sample of households. In the case of electric water heaters, both senior-only and low income consumer groups appear to benefit more from trial standard levels two through four than the total sample of households. In households with gas-fired water heaters, low income households have greater savings of average LCC for trial standard levels one through three. None of the oil-fired water heater trial standard levels show positive LCC savings, but level three shows zero LCC savings because it is the same as the baseline. Low income households with oil-fired water heaters show 25% or less of households benefitting from any of the trial standard levels.

We have noted the LCC savings for the senior-only subgroup are similar to those of the general population. Since the elderly use 30 percent less hot water on average than the general population, one would expect their costs to be lower and as a result, the LCC effect to be different. However, the standby losses of water heaters, which are not affected by hot water usage, are the same for the elderly and the general population. Therefore, since most of the design options considered affect standby losses and not water heating efficiency, we would expect the distribution of LCC impacts for the elderly to be similar to the general population.

b. Median Payback

A part of the LCC analysis is the payback analysis. The LCC payback analysis considers all of the design option combinations for each fuel type and calculates a payback for each RECS household. We report the median payback from the distribution of paybacks for each trial standard level in Table 14. The median payback is the median number of years required to recover, in energy savings, the increased costs of the efficiency improvements.

TABLE 14.—MEDIAN AND TEST PROCEDURE PAYBACK (YEARS)

[HFC–245fa Blown Insulation]

Trial standard level	Design options	Median payback	Test procedure payback[1]
1	Electric: Heat Traps + Tank Botton Insulation	2.5	1.9
	Gas: Heat Traps + Flue Baffles (78% RE) + 2 Inch Insulation	2.9	3.3
	Oil: Heat Traps	8.2	6.1
2	Electric: Heat Traps + Tank Bottom Insulation + 2 Inch Insulation	4.8	3.3
	Gas: Heat Traps + Flue Baffles (78% RE) + 2.5 Inch Insulation	3.9	4.1
	Oil: Heat Traps	8.2	6.1
3	Electric: Heat Traps + Tank Bottom Insulation + 2.5 Inch Insulation	5.4	3.7
	Gas: Heat Traps + Flue Baffles (78% RE) + 2 Inch Insulation	2.9	3.3
	Oil: Baseline	0.0	0.0
4	Electric: Heat Traps + 3 Inch Insulation + Plastic Tank	11.7	8.2
	Gas: Heat Traps + Flue Baffles (80% RE) + 3 Inch Insulation + Side Arm Heater + Plastic Tank + IID.	11.3	10.3
	Oil: Heat Traps + 3 Inch Insulation + Interrupted Ignition + Increased Heat Exchanger Area (82% RE).	24.6	15.5

[1] Electric—50 Gallon; Gas—40 Gallon; Oil—32 Gallon.

c. Test Procedure Payback

The Act states that if the Department determines that the payback period is less than three years as calculated under the water heater procedure, there shall be a rebuttable presumption that such trial standard level is economically justified. In Table 14, we list the payback periods by fuel type (product class) and trial standard levels for HFC–245fa blown insulation. The Act further states that if this three year payback is not met, this determination shall not be taken into consideration in the deciding whether a standard is economically justified. Section 325(o)(2)(B)(iii), 42 U.S.C. 6295(o)(2)(B)(iii).

Only electric water heaters at trial standard level one satisfy the rebuttable presumption. Electric water heaters with heat traps and insulated tank bottoms have a 1.9 year payback calculated under the test procedure. There are no trial standard levels for gas-fired or oil-fired water heaters that have a payback of three years or less.

2. Economic Impact on Manufacturers

We performed a MIA to determine the impact of standards on manufacturers. The complete analysis is in Chapter 13 of the TSD. In general, manufacturers stated they would be able to manufacture any of the design options with heat traps, thicker insulation, tank bottom insulation on electric and improved flue baffles on gas-fired water heaters. None of the manufacturers indicated they would leave the industry or go out of business as a result of standard levels that would require energy factors below plastic tanks or side-arm heaters (*i.e.*, trial standard levels one through three).

We conducted detailed interviews with four of the five major water heater manufacturers. The five together supply more than 99% of the U.S. residential water heater market. The interviews provided valuable information used to evaluate the impacts of an amended standard on manufacturers' cash flows, manufacturing capacities and employment levels.

We analyzed the water heater industry using two business scenarios. The standards scenario represents the investments needed to meet the energy efficiency level of a trial standard level. The cumulative scenario includes the investments required for energy efficiency improvement, changes to a new blowing agent and the development and manufacture of a gas-fired water heater resistant to ignition of flammable vapors. Additionally, we examined the ability of manufacturers to recover the investments required for each of the scenarios and trial standard levels.

The potential value of the water heater industry, represented by the INPV, ($322 million in 1998 dollars) is directly related to the manufacturers' price to the dealer/distributor. Since all five of the major manufacturers produce both gas-fired and electric water heaters, the industry is highly competitive in terms of manufacturer's pricing. Manufacturer prices are expected to increase from the current average cost to the dealer/distributor of $156 to a range of $188–299 for trial standard levels one through four. Based on comments from the interviews, we assume manufacturers will raise prices enough to recover the costs of materials, labor and transportation and 75% of their investment. If manufacturers increased water heater distributor prices slightly more, from $0.13 for trial standard level one to $2.00 for trial standard level four, they would recover all of their investment. Table 15 shows the results of the cash flow analysis with these assumptions.

TABLE 15.—MANUFACTURER IMPACT ANALYSIS

Trial Std level	INPV ($ millions)	Change in INPV		Investment required ($ millions)
		(%)	($ millions)	
Standard Scenario, HFC–5fa blown insulation				
Base Case	322	0	0	0
1	314	−3	−8	32
2	307	−5	−15	61
3	307	−5	−15	61
4	265	−18	−57	229
Cumulative Scenario, HFC–245fa blown insulation				
Base Case	322	0	0	0
1	287	−11	−35	142
2	280	−13	−42	172
3	279	−13	−43	172
4	237	−27	−85	340

From Table 15, we note energy efficiency standards could result in losses of industry net present value from about $8 million to 57 million (3–18%), while requiring investments of $32 million to 229 million. However, even if DOE did not revise energy efficiency standards, other Federal regulatory actions that will take effect on or before January 1, 2003, will result in a $27 million loss (8%) in industry NPV. This loss exceeds any of DOE's trial standard levels except level four. As requested by GRI and the SC and as required by the Process Rule, 10 CFR part 430, subpart C, appendix A 10(g)(1), DOE considered the cumulative impacts of other Federal regulatory actions on the trial standard levels, including the phase out of HCFC–141b and the CPSC initiative to prevent the ignition of flammable vapors on gas-fired water heaters. (GRI, No. 11 at 1 and SC, No. 42 at 2). These cumulative losses range from $35 million to $85 million. The investments to prevent ignition of flammable vapors and for new blowing agents are $111 million. The investments for cumulative regulations are potentially large given the current after tax profitability of the water heater industry, estimated to be $41 million (1998) on revenues of $1.3 billion.

Based on DOE's interviews, manufacturers expect little impact on manufacturing capacity and expect to meet future demand as long as standard levels based on side-arm gas-fired water heaters and plastic tank electric units are not mandated. Currently, the U.S. industry has far more manufacturing capacity than the domestic market can absorb. Manufacturers estimated the industry is operating at 60–80% of total capacity. Due to the phase-out of HCFC–141b insulation blowing agent and a requirement for a gas-fired water heater resistant to ignition of flammable vapors, it is likely that nearly every product line would have to be redesigned, retested and re-certified. Several manufacturers indicated a preference to retool for new blowing agents, energy-efficiency standards and flammable vapor-resistant designs at the same time, to avoid redundant efforts and limit costs.

We also used the manufacturers' interviews to assess employment impacts due to an amended energy efficiency standard. Manufacturers expected the impact of new blowing agents and flammable vapor resistant designs on labor to be minimal, neither increasing nor reducing employment levels by more than a few employees. Unless efficiency levels requiring the adoption of side arm heaters or plastic tanks are mandated, manufacturers do not anticipate significant changes in employment levels or training requirements. Additionally, we believe market growth of 2.5% per year for new homes and modest productivity gains ensure current employment levels for the foreseeable future. In our analysis, yearly water heater shipments range from 9.7 million in 1999 to 19.5 in 2030. Furthermore, a replacement market that increases by about 1/10th of the new home market each year ensures future demand.

B. Significance of Energy Savings

The Act prohibits the Department from adopting a standard for a product if that standard would not result in ''significant'' energy savings. Section 325(o)(3)(B), 42 U.S.C. 6295(o)(3)(B). While the term ''significant'' is not defined in the Act, the U.S. Court of Appeals, in *Natural Resources Defense Council* v. *Herrington*, 768 F.2d 1355, 1373 (D.C. Cir. 1985), ruled that Congress intended ''significant'' energy savings to be savings that were not ''genuinely trivial.'' The energy savings for all of the trial standard levels considered in this rulemaking are non-trivial and therefore we consider them ''significant'' within the meaning of Section 325 of the Act.

National Energy Savings. To estimate the energy savings through the year 2030 due to amended standards, we compared the energy consumption of water heaters in the 2003 baseline to the energy consumption of water heaters complying with the trial standard levels. DOE calculates these energy savings at the source using the NEMS–BRS distribution and generation losses. This addresses stakeholders' comments that a source-based analysis is a more accurate measurement of the total energy being used. (Clearwater, No. 30 at 1 and NGC, No. 59 at 1). Table 16 shows these results for water heaters with HFC–245fa blown insulation.

TABLE 16.—SOURCE ENERGY SAVINGS WITH HFC–245FA BLOWN INSULATION (QUADS)

	Trial Std 1	Trial Std 2	Trial Std 3	Trial Std 4
Total Quads Saved	3.4	4.3	4.8	13.1
Total Exajoules Saved	3.6	4.5	5.0	13.8

All of the trial standard levels considered in this rulemaking have significant energy savings, ranging from 3.4 quads (3.6 Exajoules (EJ)) to 13.1 quads (13.8 EJ), depending on the trial standard level.

National Net Present Value. Additionally, we analyzed the economic impact on the nation to year 2030. This is a NPV analysis using the AEO99 reference energy prices. Table 17 lists the NPV for HFC–245fa blown insulation. The NPV considers the combined discounted energy savings minus increased consumer costs of the four fuel types of equipment at a particular trial standard level. We base this calculation on all expenses and savings occurring between 2003 and 2030.

TABLE 17.—NATIONAL NET PRESENT VALUE

Trial standard level	NPV—HFC–245fa ($ billions)
1	2.3
2	1.5
3	3.3
4	−17.4

The national NPV is positive for trial standard levels one through three. In this analysis, a positive NPV means that the estimated energy savings are greater than the increased costs due to standards. Among the trial standard levels analyzed, trial standard level three has the highest NPV.

C. Lessening of Utility or Performance of Products

None of the trial standard levels reduces the performance of water heaters. Generally, the trial standard levels reduce heat losses and improve heat exchanger effectiveness. These changes improve energy and water heating performance and may increase the amount of water available in one hour, i.e., the first hour rating.

However, to reduce heat losses, it is necessary to use thicker insulation. The trial standard levels contemplate thicker insulation of 2.5–3 inches versus the 1–2 inches in common use today. This extra thickness of insulation will make water heaters larger and more difficult to squeeze into tight spaces when replacing a water heater. DOE does not believe any model of water heater will become unavailable as a result of thicker insulation. In those applications where thicker insulation could cause problems, we believe possible solutions include smaller tanks with larger heating elements, taller tanks, more effective insulation, *e.g.*, space blanket, or perhaps instantaneous water heaters. Instantaneous water heaters generally have characteristics such as, initiating water heating based on sensing water flow, a higher heating rate and storage capacities less than two gallons.

However, a number of manufacturers and other stakeholders believe that thicker insulation will reduce product utility or adversely impact consumers. (Bradford White, No. 74 at 2; GAMA, No. 71 at 4 and No. 91 at 1; CNG, No. 85 at 2; NEGA, No. 90 at 3; Rheem, No. 95 at 1; SC, No. 84 at 2; and AGA, No. 92 at 9). There may be replacement applications where manufacturers can only meet the demand for replacement water heaters with a slightly smaller tank. DOE has investigated this with water heater manufacturers and home builders and is aware that some replacement applications may be unable to accommodate the tank size currently used.

ACEEE claimed manufacturers can make water heaters taller or wider to fit most of the installation situations encountered. (ACEEE, No. 93 at 8). OOE stated the industry can find the additional space for insulation by reducing the storage tank diameter. This will only reduce tank volume by 2–3 gallons, according to OOE. (OOE, No. 96 at 5). In another approach, Battelle suggested manufacturers could increase the firing rate, set point, and heat transfer rate of gas-fired water heaters so they could reduce tank size without sacrificing any first-hour rating. (Battelle, No. 66 at 8 and No. 83 at 11). We estimate external dimensions for electric water heaters could be maintained at approximately current sizes, if tank volume were reduced about 20%, coupled with a 1.35 kW increase in the heating rate, from 4.5–5.85 kW. This would restore the first hour rating and a 6 kW heating element as a common size, see Chapter 3.4.4 in the TSD. We recognize the increased heating element wattage may overload some existing electrical circuits. We request comments on these suggestions and the extent that product utility might be affected.

Further, DOE requests engineering data or other information that will substantiate claims of reduced product utility and an explanation of the specific impact that would be anticipated. We are particularly interested in comments on the number of households that may be affected and whether these households are in a particular geographic region or income strata.

D. Impact of Lessening of Competition

The Act directs the Department to consider any lessening of competition that is likely to result from standards. It further directs the Attorney General to determine the impact, if any, of competition likely to result from such standard and transmit such determination, not later than 60 days after the publication of a proposed rule to the Secretary, together with an analysis of the nature and extent of such impact. Section 325(o)(2)(B)(i)(V), 42 U.S.C. 6295(o)(2)(B)(i)(V).

In order to assist the Attorney General in making such a determination, the Department has provided the Department of Justice (DOJ) with copies of this notice and the TSD for review. At DOE's request, the DOJ reviewed the manufacturer impact analysis interview questionnaire to ensure that it would provide insight concerning any lessening of competition due to any proposed trial standard levels.

In response to a comment from the AGA, DOE requested the DOJ's view as to whether the "lessening of competition" language in Section 325(o)(2)(B)(i)(V), 42 U.S.C. 6295(o)(2)(B)(i)(V) applies to energy suppliers. (AGA, No. 49 at 6). In its letter dated June 25, 1999, the DOJ replied that "we would consider not only evidence of the effect on competition among water heater manufacturers, but also information relating to the likely effect on competition among energy suppliers." However, the DOJ added they would focus on the effect of standards "on the overall level of market competition, not on individual fuel suppliers or on shifts in consumer usage among alternate fuels."

E. Need of the Nation To Save Energy and Net National Employment

1. Environmental Impacts

Enhanced energy efficiency improves the Nation's energy security, strengthens the economy and reduces the environmental impacts of energy production. The energy savings from water heater standards result in reduced emissions of CO_2, SO_2 and NO_X and aids in addressing global climate change and reducing air pollution. Depending on the standard level chosen, the cumulative emission reductions to 2030 range from 48–219 Mt for carbon equivalent, 141–599 thousand metric tons (kt) for NO_X, and −6 to 54 kt for SO_2. The large reductions in CO_2 and NO_X at all standard levels are a positive benefit to the nation. We show cumulative emissions savings from 2003–2030 in Table 18.

EEI, SC and VP claimed in-house combustion also will produce carbon monoxide (CO), particulates, and volatile organic compounds (VOCs), yet they are not included in the environmental analysis. (EEI, No. 39 at 4 and No. 79 at 1; SC, No. 84 at 2; and VP, No. 45 at 3). Properly functioning appliances should not emit CO. Additionally, particulates and hydrocarbon emissions from appliances are very, very small. Therefore, we assumed CO and particulate emissions reductions resulting from proposed energy standards are negligible.

TABLE 18.—CUMULATIVE EMISSIONS REDUCTIONS THROUGH 2030

Emission	Trial Std level 1	Trial Std level 2	Trial Std level 3	Trial Std level 4
Carbon (Mt)	48	74	83	219
NO_X (kt)	141	208	229	599
SO_2 (kt)	**4	**<1	** −6	**54

**Results only include household SO_2 emissions reductions because SO_2 emissions from power plants are capped by clean air legislation. Thus, SO_2 emissions will only be negligibly affected by possible water heater standards.

2. Net National Employment

In the Process Rule, DOE committed to develop estimates of the employment impacts of proposed standards in the economy in general. The results of the Department's analysis are shown in Chapter 15 of the TSD.

While both this input/output model and the direct use of BLS employment data suggest the proposed water heater standards could increase the net demand for labor in the economy, the gains would most likely be very small relative to total national employment. For several reasons, however, even these modest benefits for national employment are in doubt:

- Unemployment is now at the lowest rate in 30 years. If unemployment remains very low during the period when the proposed standards are put into effect, it is unlikely that the standards could result in any net increase in national employment levels.
- Neither the BLS data nor the input-output model used by DOE include the quality or wage level of the jobs. One reason that the demand for labor increases in the model may be that the jobs expected to be created pay less than the jobs being lost. The benefits from any potential employment gains would be reduced if job quality and pay are reduced.
- The net benefits from potential employment changes are a result of the estimated net present value of benefits or losses likely to result from the proposed standards, it may not be appropriate to separately identify and consider any employment impacts beyond the calculation of net present value.

Taking into consideration these legitimate concerns regarding the interpretation and use of the employment impacts analysis, the Department concludes only that the proposed water heater standards are likely to produce employment benefits that are sufficient to offset fully any adverse impacts on employment in the water heater or energy industries.

F. Conclusion

1. Comments on Standard Levels

In order to inform interested stakeholders, we released our preliminary analysis results and convened a workshop to receive comments on what standard might be supported by the results. Below is a short summary of the type of comments we received on our preliminary analysis. We have considered these comments when selecting the proposed standard level. Many of the comments suggest actions that are already a part of the process we use to select a standard.

SC stated minimum efficiency levels should be set so that the majority of consumers benefit from the new standards. SC suggested if at least 85% of the population benefitted, it would be unlikely that any particular subgroup of customers would suffer substantial loss from the proposed standard. (SC, No. 42 at 3). CNG and NEGA stated any standard above trial standard level one (use EFs from July Workshop) is too costly for consumers and may affect safety. (CNG, No. 85 at 1 and NEGA, No. 90 at 1). When we select a standard level, we weigh the overall benefits and burdens. We do not base our decision on any particular fraction of the population that benefits.

Several comments claimed DOE should keep new standards fuel neutral (EEI, No. 79 at 2 and American Electric

Power, No. 87 at 1). The National Rural Electric Cooperative Association (NRECA) claimed gas-fired and electric water heaters should have the same 0.03 increase in energy factor using thicker insulation and heat traps. (NRECA, No. 2 at 2). EEI and American Electric Power wanted DOE to keep new standards fuel neutral by raising energy factors for all fuel types.

Other comments made specific recommendations for gas-fired and electric water heaters. PG&E claimed DOE should set the new standards for electric and gas-fired water heaters at the highest levels that can be achieved with conventional technologies, *e.g.*, 0.60 EF for gas-fired water heaters that are common in southern California. (PG&E, No. 94 at 3). ACEEE claimed that according to DOE's July 1997 analysis, the minimum LCC point is 0.91 EF for a 50-gallon electric and 0.61 EF for a 40-gallon gas-fired water heater when using HFC–245fa blown insulation. Furthermore, ACEEE believes this is what DOE should propose as the new standard in the NOPR. (ACEEE, No. 93 at 9). Bradford White recommended that electric and oil standards should remain the same and gas-fired water heater standards should be raised by 0.02 EF. (Bradford White, No. 89 at 5).

ACEEE claimed DOE should consider a gas-fired water heater with an 80% flue baffle, 2 inches of insulation and heat traps because it appears to be the minimum LCC. (ACEEE, No. 93 at 2). In our revised analysis, the lowest LCC for a gas-fired water heater is a 78% flue baffle with 2 inches of insulation and heat traps. To verify that we did not overlook any economically justified trial standard, we analyzed a gas-fired water heater with an 80% flue baffle and 2 inches of insulation. This standard level resulted in a negative LCC savings, negative manufacturers' impact and negative NPV so we concluded it is not economically justified.

2. Proposed Standard

Section 325(o)(2)(A), 42 U.S.C. 6295(o)(2)(A), of the Act specifies that any new or amended energy conservation standard for any type (or class) of covered product shall be designed to achieve the maximum improvement in energy efficiency which the Secretary determines is technologically feasible and economically justified. In determining whether a standard is economically justified, the Secretary must determine whether the benefits of the standard exceed its burdens. Section 325(o)(2)(B)(i), 42 U.S.C. 6295(o)(2)(B)(i). The amended standard must ''result in significant conservation of energy.'' Section 325(o)(2)(B)(iii)(3)(B), 42 U.S.C. 6295(o)(B)(iii)(3)(B). The Secretary has eliminated the maximum technologically feasible levels for electric and gas-fired water heaters, but we are analyzing the maximum technologically feasible level for oil-fired water heaters. See Section III.D.2 of this notice. All of the design options included in our analysis are technologically feasible since they are commercially available.

As discussed in section IV.A, we consider the impacts of standards at each of four standards levels, beginning with the most efficient level, *i.e.*, standard level four. We then consider less efficient levels. Standard levels three and two are combinations of different efficiency levels for the different classes. For gas-fired water heaters, standard levels three and one are the same, though lower efficiency than that found in standard level two. For electric water heaters, no standard levels are repeated and the efficiency of each lower standard level is lower than that found in higher standard levels. Finally, for oil-fired water heaters, standard levels two and one are the same and level three is no change from the current standard. By combining efficiency levels in this way, the Department is able to evaluate the impacts of different combinations of standard levels to make an informed decision on the merits of different efficiency combinations.

To aid the reader as we discuss the benefits or burdens of the trial levels we have included a summary of the analysis results in Table 19.

TABLE 19.—SUMMARY ANALYSIS RESULTS BASED ON HFC–245FA BLOWN INSULATION

	Trial Std 1	Trial Std 2	Trial Std 3	Trial Std 4
Total Quads Saved	3.4	4.3	4.8	13.1
NPV ($Billion)	2.2	1.5	3.4	−17.4
Emissions:				
Carbon Equivalent (Mt)	48	74	83	219
NO_X (kt)	141	208	229	599
SO_2 (kt)	**4	**<1	**−6	**54
Cumulative Change in INPV ($ Million)	−8	−15	−15	−57
Life Cycle Cost ($):				
Electric	32	36	40	−55
Gas-Fired	43	34	43	−215
Oil-Fired	−20	−20	0	−447

**Results only include household SO_2 emissions reductions because SO_2 emissions from power plants are capped by clean air legislation. Thus, SO_2 emissions will only be negligibly affected by possible water heater standards.

We first considered trial standard level four, the most efficient level for each of the three classes. Trial standard level four saves about 13.1 quads of energy, a significant amount. The emissions reductions of 219 Mt of carbon equivalent, 599 kt of NO_X, and 54 kt of SO_2 are significant. However, at this level, consumers experience negative LCC impacts. They would lose $55 (with electric water heaters), $193 (with gas-fired water heaters) and $459 (with oil-fired water heaters). Furthermore, the water heater industry would lose 27% of its value and the nation would have a loss in NPV of more than $17 billion. The Department concludes the resulting energy savings and emission reductions at this level are outweighed by the negative economic impacts on the nation, consumers and manufacturers. Consequently, the Department concludes trial standard level four is not economically justified.

Next, we considered trial standard level three. This trial standard level saves about 4.8 quads of energy, a significant amount. The emissions reductions are significant: 83 Mt of carbon equivalent and 229 kt of NO_X. There is a small increase in household emissions of SO_2 (6 kt) due to a slight increase in shipments of oil-fired water heaters. The national NPV of trial standard level three is $3.4 billion from 2003–2030.

The economic benefits to consumers are significant. The average LCC savings for consumers with electric and gas-fired water heaters are $40 and $43 respectively and there are no impacts on users of oil-fired water heaters. In trial standard level three, 87% of households with gas-fired water heaters have LCC savings, for an average savings of $57, while 13% experience LCC losses, for an average loss of $52. For households with electric water heaters, 74% of households have LCC savings, for an average savings of $64, while 26% experience LCC losses, for an average loss of $27.

For electric water heaters, the analysis predicts that 26 percent of all consumers would experience no change or some net cost with more efficient electric water heaters. However, we believe that there are costs or savings near the point of zero change in LCC that consumers would be unable to distinguish in their yearly expenses. We have chosen ±2 percent of average baseline LCC as the band of no consumer impact. We believe this small percentage, regardless of the actual total LCC, is insignificant to the consumer because these LCC costs or savings are spread over monthly utility bills for the life of the water heater. By applying a 2% band of average LCC, we can clearly show the significant net savings and net costs associated with a trial standard level. This permits a more informed decision based on weighing the significant benefits and burdens in terms of consumer impact. The resulting ranges are shown in Figure 9.6.2a in the TSD.

We will use ±2 percent of baseline LCC to indicate no impact, positively or negatively, on consumers. Therefore, only 4 percent of consumers in the case of electric water heaters or 6 percent of consumers in the case of gas water heaters sustain any significant net costs under the proposed standard level for water heaters. Similarly, 35 percent of consumers in the case of electric water heaters or 62 percent of consumers in the case of gas water heaters have significant net savings.

Two percent of average baseline LCC equals $51 for electric water heaters. Over the average life of 12 years for an electric water heater, this is less than $4.50 per year. For consumers with gas-fired water heaters, two percent of average baseline LCC is $30. Over the average life of 9 years for a gas water heater, this is less than $3.50 per year. We believe this is a small amount in terms of yearly expenditures and will not adversely impact consumers' purchase decisions about water heaters, or their financial positions.

Additionally, low-income and senior-only consumer subgroups exhibit similar distributions of costs and savings. A similar small percentage of low-income or senior only consumers are affected by higher costs.

The industry will lose about 5% ($15 million) of its INPV due to energy efficiency standards. These losses are more than balanced by NPV gains to the nation of $3.3 billion, or 220 times the industry losses. Industry losses for trial standard level three due to all Federal actions (CPSC, EPA and DOE) are 13% of its INPV, or $43 million. Even this level of losses is offset by gains to the nation that are 77 times the industry losses.[2] Based on the manufacturer interviews, DOE believes there will not be any plant closures or employee layoffs.

In determining the economic justification of trial standard level three, the Department has weighed the benefits of energy savings, reduced average consumer LCC, significant and positive NPV, and emissions reductions and the burdens of a loss in manufacturer net present value, and consumer LCC increases for some households. After carefully considering the results of the analysis, DOE has determined the benefits of trial standard level three outweigh its burdens and is economically justified. The Department also concludes trial standard level three saves a significant amount of energy and is technologically feasible.[3] Therefore, the Department today proposes to adopt the energy conservation standards for water heaters at trial standard level three.

V. Procedural Reviews

A. Review Under the National Environmental Policy Act

In issuing the March 4, 1994, Proposed Rule for energy efficiency standards for eight products, one of which was water heaters, the Department prepared an Environmental Assessment (DOE/EA–0819) that was published within the Technical Support Document for that Proposed Rule. (DOE/EE–0009, November 1993). The environmental effects associated with various standard levels for water heaters, as well as the other seven products, were found not to be significant, and a Finding of No Significant Impact (FONSI) was published. (59 FR 15868, April 5, 1994).

In conducting the analysis for this Proposed Rule, the DOE evaluated several design options suggested in comments to the screening document. As a result, the energy savings estimates and resulting environmental effects from revised energy efficiency standards for water heaters in this Proposed Rule differ somewhat from those presented for water heaters in the 1994 Proposed Rule. Nevertheless, the environmental effects expected from the energy efficiency standards considered for this Proposed Rule fall within the ranges of environmental impacts from the revised energy efficiency standards for water heaters that DOE found in the 1994 FONSI not to be significant.

B. Review Under Executive Order 12866, ''Regulatory Planning and Review''

The Department has determined today's regulatory action is a significant regulatory action within the scope of Section 3(f)(1) of Executive Order 12866, ''Regulatory Planning and Review.'' (58 FR 51735, October 4, 1993). Therefore, this proposal requires a regulatory analysis. Such an analysis presents major alternatives to the proposed regulation that could achieve substantially the same goal, as well as a description of the cost and benefits (including potential net benefits) of the proposed rule. Accordingly, the Office of Information and Regulatory Affairs (OIRA) reviewed today's action under the Executive Order.

There were no substantive changes between the draft we submitted to OIRA and today's action. The draft and other documents we submitted to OIRA for review are a part of the rulemaking record and are available for public review in the Department's Freedom of Information Reading Room, 1000 Independence Avenue, SW, Washington, DC 20585, between the hours of 9:00 a.m. and 4:00 p.m., Monday through Friday, except Federal holidays, telephone (202) 586–3142.

The following summary of the Regulatory Impact Analysis (RIA) focuses on the major alternatives considered in arriving at the proposed approach to improving the energy

[2] As DOE has determined, the benefits of today's proposal outweigh the $15 million loss to the industry. To review the support for this determination, see the TSD at Chapters 12.5 and Table 12.1a, 13.3.3.5 and Table 13.8a, 13.3.4, and 13.3.5.

[3] The proposed standard is based on insulation blown with HFC–245fa. We also analyzed the impact of using water-blown insulation. We found the benefits of LCC savings, emission reductions, and NPV are lower, and manufacturers' losses are higher using water blown insulation compared to using HFC–245fa blown insulation. The energy savings and water heater performance are also lower because water blown insulation is 42% less effective than HFC–245fa blown insulation.

If, based on comments on today's proposed rule, DOE were to conclude that insulation with energy conservation characteristics similar to HFC–245fa blown insulation will not be available at the effective date of the standard, DOE would use the water blown insulation analysis as a basis for its final decision.

efficiency of consumer products. The reader is referred to the complete RIA, which is contained in the TSD, available as indicated at the beginning of this NOPR. It consists of: (1) A statement of the problem addressed by this regulation, and the mandate for government action; (2) a description and analysis of the feasible policy alternatives to this regulation; (3) a quantitative comparison of the impacts of the alternatives; and (4) the economic impact of the proposed standard.

The RIA calculates the effects of feasible policy alternatives to water heater energy efficiency standards, and provides a quantitative comparison of the impacts of the alternatives. We evaluate each alternative in terms of its ability to achieve significant energy savings at reasonable costs, and we compare it to the effectiveness of the proposed rule.

We created the RIA using a series of regulatory scenarios (with various assumptions), which we used as input to the shipments model for water heaters. We used the results from the shipments model as inputs to the NES spreadsheet calculations.

DOE identified the following seven major policy alternatives for achieving consumer product energy efficiency. These alternatives include:

- No New Regulatory Action
- Informational Action
- Product Labeling
- Consumer Education
- Prescriptive Standards
- Financial Incentives
  —Tax credits
  —Rebates
  —Low income and seniors subsidy
- Voluntary Energy Efficiency Targets (5 Years, 10 Years)
- Mass Government Purchases
- The Proposed Approach (Performance Standards)

We have evaluated each alternative in terms of its ability to achieve significant energy savings at reasonable costs (Table 20), and have compared it to the effectiveness of the proposed rule.

TABLE 20.—ALTERNATIVES CONSIDERED

Policy Alternatives	NPV ($ in billions)	Energy Savings Quads
Consumer Product Labeling	−0.009	0.077
Consumer Education	0.439	0.539
Prescriptive Standards	1.149	0.78
Consumer Tax Credits	0.333	0.163
Consumer Rebates High Efficiency	0.349	0.174
Consumer Rebates Heat Pump	1.164	0.586
Low Income and Seniors Subsidy	1.011	0.415
Manufacturer Tax Credits	0.074	0.039
Voluntary Efficiency Target (5 year delay)	1.47	2.887
Voluntary Efficiency Target (10 year delay)	0.882	2.211
Mass Government Purchases	0.012	0.057
Performance Standards	3.433	4.746

NPV = Net Present Value (2003–2030, in billion 1998 $) (does not include government expenses).
Savings = Energy Savings (Source Quads).

If we imposed no new regulatory action, then we would implement no new standards for this product. This is essentially the ‘‘base case’’ for water heaters. In this case, between the years 2003 and 2030, there would be an expected energy use of 120.91 Quads (127.56 Exajoules (EJ)) of primary energy, with no energy savings and a zero NPV.

We grouped several alternatives to the base case under the heading of informational action. They include consumer product labeling and DOE public education and information programs. Both of these alternatives are already mandated by, and are being implemented under EPCA, as amended, Sections 324 and 337, 42 U.S.C. 6294, 6297. One base case alternative would be to estimate the energy conservation potential of enhancing consumer product labeling. To model this possibility, the Department estimated that 5 percent of consumers change their decisions on which water heater to buy based on a consumer product labeling program. The consumer product labeling alternative resulted in 0.077 quad (0.081 EJ) of energy savings with a negative $0.009 billion NPV.

Another approach, called consumer education, is to consider an Energy Star® program for heat pump water heaters. We assume, under this program, sales would jump to 150,000 units per year in 2008 and continue to be constant after that. This estimate is based on an Arthur D. Little (ADL) report from October 20, 1997, ‘‘Low Cost Heat Pump Water Heater Status Report.’’ We calculated the fraction that this represents of the baseline electric water heater market share in 2008, and subtracted this fraction from the next lowest design option with any market share. This consumer education program would perform somewhat better than product labeling with energy savings equal to 0.539 Quad (0.57 EJ) and $0.439 billion NPV.

Another method of setting standards would entail requiring that certain design options be used on each product, i.e., for DOE to impose prescriptive standards. For this approach, we assume that a prescriptive standard is implemented as a standard at the next lower trial standard level than the performance standard level, i.e., we would implement a prescriptive standard at trial standard level two. The reduced flexibility afforded to manufacturers of a prescriptive standard would make it difficult for manufacturers to achieve the higher level. The lower standard level entails slightly smaller expenditures for retooling and purchasing parts. Consequently, the economic impacts we expect before the implementation date should be slightly smaller for prescriptive standards. This resulted in energy savings of 0.78 Quad (0.82 EJ) and $1.15 billion NPV.

We tested various financial incentive alternatives. These included tax credits and rebates to consumers, as well as tax credits to manufacturers. We assumed the tax credits to consumers were 50% of the incremental purchase expense for higher energy-efficiency water heaters. The incremental cost is based on the difference between the 2003 baseline cost and the cost of a 50-gallon 0.91 EF electric, a 40-gallon 0.60 EF gas-fired, and a 32-gallon 0.61 EF oil-fired water heater. We estimate the impact of this policy is to move 5% of the market share from the 2003 baseline to the more efficient models. These tax credits start in 2003 and run for six years. We assume people stop buying these more efficient and more expensive water heaters when the tax credits stop. The tax credits to consumers showed a change from the base case, saving 0.163 Quad (0.17 EJ) with $0.333 billion NPV.

To estimate the impact of consumer rebates, DOE assumed rebates of 35% of the incremental retail prices for more energy-efficient water heaters. The incremental cost is based on the difference between the 2003 baseline cost and the cost of a 50-gallon 0.91 EF electric, a 40-gallon 0.60 EF gas-fired, and a 32-gallon 0.61 EF oil-fired water heater. We estimate the impact of this policy is to move 5% of market share from the 2003 baseline to the more efficient models. These rebates start in 2003 and run for six years and we assume people stop buying these more efficient and more expensive water heaters when the rebates stop. Consumer rebates would save 0.174 Quad (0.18 EJ) with $0.349 billion NPV.

We also considered a consumer rebate alternative that was equal to the difference between the retail cost of a heat pump water heater and a 0.91 EF electric resistance water heater. This rebate is only applied to new construction because heat pumps may require more closet space and more air space from which to remove heat. We estimated the installed costs of heat pump water heaters ($875) and market penetration levels (300,000 units per year) based on ADL data on drop-in heat pump water heaters. We assumed these rebates run for six years and we assume people stop buying these more efficient and more expensive water heaters when the rebates stop. We estimated this rebate alternative would save 0.586 Quad (0.62 EJ) and produce $1.164 billion NPV.

One of the market barriers to higher efficiency gas-fired water heaters is the expense to upgrade venting systems. Another market barrier for electric and gas-fired water heaters is the expense to enlarge small closets or to relocate water heaters with thicker insulation when they will not fit into an existing space. Since these expenses can be a particular burden on low income and seniors-only households, we considered a low income and seniors-only subsidy of $100 to make higher efficiency water heaters available and cost effective for these households. We determined the number of low income and seniors only households from the RECS public use data. The program starts in 2003 and runs for six years. This subsidy saved 0.415 Quad (0.44 EJ) with $1.011 billion NPV.

Another financial incentive we considered was a tax credit to manufacturers for the production of energy-efficient models of water heaters. We assumed an investment tax credit of 20%, applicable to the tooling and machinery costs of the manufacturers. These are tooling costs as they relate to producing a 0.91 EF on a 50-gallon electric, a 0.60 EF on a 40-gallon gas-fired, and a 0.61 EF on a 32-gallon oil-fired water heater. We estimate the impact of this policy is to move 1% of the market share from the 2003 baseline to the more efficient models. These tax credits start in 2003 and run for six years. We assume no persistence in the market once they stop. Tax credits to manufacturers would save 0.039 Quad (0.41 EJ) and produce $0.074 billion NPV.

The impact of this scenario produces small savings because the investment tax credit was applicable only to the tooling and machinery costs of the firms. The firms' fixed costs and some of the design improvements that would likely be adopted to manufacture more efficient versions of this product would involve purchased parts. Expenses for purchased parts would not be eligible for an investment tax credit.

We examined two scenarios of voluntary energy efficiency targets. In the first one, we assumed all the relevant manufacturers voluntarily adopted the proposed energy conservation standards in five years. In the second scenario, we assumed the proposed standards were adopted in 10 years. In these scenarios, voluntary improvements having a five-year delay, compared to implementation of mandatory standards, would result in energy savings of 2.887 Quads (3.05 EJ) and $1.469 billion NPV; voluntary improvements having a 10-year delay would result in 2.211 Quads (2.33 EJ) being saved and $0.882 billion NPV. These scenarios assume that there would be universal voluntary adoption of the energy conservation standards by these appliance manufacturers, an assumption for which there is no assurance.

Another policy alternative we reviewed was that of large purchases of high efficiency electric and gas-fired water heaters by Federal, State, and local governments. We modeled this policy by assuming these governmental entities (i.e., U.S. Department of Housing and Urban Development and DOE at the Federal level) purchased high efficiency water heaters for 5% of the low income, rented housing. This policy alternative resulted in energy savings of 0.057 Quad (0.06 EJ) and $0.012 billion NPV.

Lastly, all of these alternatives must be gauged against the performance standards we are proposing in this NOPR. Such performance standards would result in energy savings of 4.746 Quads (5.00 EJ), and the NPV would be an expected $3.443 billion.

As indicated in the paragraphs above, none of the alternatives we examined for these products would save as much energy as the Proposed Rule. Also, several of the alternatives would require new enabling legislation, since authority to carry out those alternatives does not presently exist.

C. Review Under the Regulatory Flexibility Act

The Regulatory Flexibility Act of 1980, 5 U.S.C. 601–612 (Pub. L. 96–354) requires an assessment of the impact of regulations on small businesses. The Small Business Administration's definition for small business in the water heater industry is one that employs 500 or fewer employees.

The water heater industry is characterized by five firms accounting for nearly 99% of sales. Smaller businesses and firms, which make specialty water heaters and supply niche markets, share 1% of the market. We are aware of three small firms: Bock Water Heaters, Heat Transfer Products, and Vaughn.

Of the three small firms, Bock manufactures oil-fired water heaters that have not been affected by this proposed rule. Therefore, we do not think that this firm will suffer any adverse impacts to the rule. The other two firms, Heat Transfer and Vaughn, both make electric water heaters that are considered in this rule. In the GAMA directory, these firms only list electric water heaters that meet or exceed the standard level contemplated in this rule. The proposed rule may raise the standard level enough to impact their niche market for high efficiency electric water heaters. However, these manufacturers also manufacture very long life products that incorporate other features which will help them preserve their niche market. The Department has taken this into consideration in this rulemaking.

The Department prepared a manufacturing impact analysis that it shared with all the water heater manufacturers. The smaller manufacturers did not choose to discuss the impacts of the trial standard levels on their firms.

In view of the information discussed above, the Department has determined and hereby certifies pursuant to Section 605(b) of the Regulatory Flexibility Act that, for this particular industry, the proposed standard levels in today's Proposed Rule will not ''have a significant economic impact on a substantial number of small entities,'' and it is not necessary to prepare a regulatory flexibility analysis.

D. Review Under the Paperwork Reduction Act

No new information or record keeping requirements are imposed by this rulemaking that would require Office of Management and Budget clearance under the Paperwork Reduction Act. 44 U.S.C. 3501 *et seq.*

E. Review Under Executive Order 12988, ''Civil Justice Reform''

With respect to the review of existing regulations and the promulgation of new regulations, Section 3(a) of Executive Order 12988, ''Civil Justice Reform,'' 61 FR 4729 (February 7, 1996), imposes on Executive agencies the general duty to adhere to the following requirements: (1) Eliminate drafting errors and ambiguity; (2) write regulations to minimize litigation; and (3) provide a clear legal standard for affected conduct rather than a general standard and (4) promote simplification and burden reduction.

With regard to the review required by Section 3(a), Section 3(b) of Executive Order 12988 specifically requires that Executive agencies make every reasonable effort to ensure that the regulation: (1) Clearly specifies the preemptive effect, if any; (2) clearly specifies any effect on existing Federal law or regulation; (3) provides a clear legal standard for affected conduct while promoting simplification and burden reduction; (4) specifies the retroactive effect, if any; (5) adequately defines key terms; and (6) addresses other important issues affecting clarity and general draftsmanship under any guidelines issued by the Attorney General. Section 3(c) of Executive Order 12988 requires Executive agencies to review regulations in light of applicable standards in Section 3(a) and Section 3(b) to determine whether they are met or it is unreasonable to meet one or more of them. DOE reviewed today's proposed rule under the standards of Section 3 of the Executive Order and determined that, to the extent permitted by law, these proposed regulations meet the relevant standards.

F. ''Takings'' Assessment Review

The Department has determined pursuant to Executive Order 12630, ''Governmental Actions and Interference with Constitutionally Protected Property Rights,'' 53 FR 8859 (March 18, 1988) that this regulation would not result in any takings that might require compensation under the Fifth Amendment to the United States Constitution.

G. Review Under Executive Order 13132, ''Federalism''

Executive Order 13132 (64 FR 43255, August 10, 1999) requires agencies to develop an accountable process to ensure meaningful and timely input by State and local officials in the development of regulatory policies that have ''federalism implications.'' Policies that have federalism implications are defined in the Executive Order to include regulations that have ''substantial direct effects on the States, on the relationship between the national government and the States, or on the distribution of power and responsibilities among the various level of government.'' Under Executive Order 13132, DOE may not issue a regulation that has federalism implications, that imposes substantial direct costs, and that is not required by statute, unless the Federal government provides the funds necessary to pay the direct compliance costs incurred by the State and local governments, or DOE consults with State and local officials early in the process of developing the proposed regulation. DOE also may not issue a regulation that has federalism implications and that preempts State law unless it consults with State and local officials early in the process of developing the proposed regulations.

The statutory authority under which this proposed standard is being promulgated specifically addresses the effect of Federal rules on State laws or regulations concerning testing, labeling and standards. Section 327 of EPCA, as amended, 42 U.S.C. 6297. Generally all such State laws or regulations are superseded by EPCA, unless specifically exempted in Section 327. The Department can grant a waiver of preemption in accordance with the procedures and other provisions of Section 327(d) of the Act, as amended. 42 U.S.C. 6297(d). States can file petitions for exemption from preemption with the Secretary and have their request reviewed on a case-by-case basis.

DOE has examined today's rule and has determined that although final standards would preempt State laws in this area, they 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. No further action is required by Executive Order 13132.

H. Review Under the Unfunded Mandates Reform Act of 1995

With respect to a proposed regulatory action 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 (adjusted annually for inflation) in any one year, Section 202(a) of the Unfunded Mandates Reform Act of 1995 (UMRA), 2 U.S.C. 1531 *et seq.* requires a Federal agency to publish a written statement concerning estimates of the resulting costs, benefits and other effects on the national economy. 2 U.S.C. 1532(a), (b). DOE estimates that the proposed standards, if adopted, would result in the expenditure by the private sector of $100 million or more in a year.

Section 202 of UMRA authorizes an agency to respond to the content requirements of UMRA in any other statement or analysis that accompanies the proposed rule. 2 U.S.C. 1532(c). The content requirements of Section 202(a) of UMRA relevant to the private sector mandate substantially overlap the economic analysis requirements that apply under Section 325(o) of EPCA, as amended, and Executive Order 12866. The Supplementary Information section in this NOPR and the analysis contained in the TSD for this proposed rule responds to those requirements.

DOE is obligated by Section 205 of UMRA, 2 U.S.C. 1535, to identify and consider a reasonable number of regulatory alternatives before promulgating a rule for which a written statement under Section 202 is required. From those alternatives, DOE must select the least costly, most cost-effective or least burdensome alternative that achieves the objectives of the rule, unless DOE publishes an explanation of why a different alternative is selected. As required by Section 325(o) of the EPCA, as amended, 42 U.S.C. 6295(o), this proposed rule would establish energy conservation standards for water heaters that are designed to achieve the maximum improvement in energy efficiency which DOE has determined is technologically feasible and economically justified. A full discussion of the regulatory and non-regulatory alternatives considered by DOE is presented in the TSD for this proposed rule.

I. Review Under the Plain Language Directives

Section 1(b)(12) of Executive Order 12866 requires that each agency draft its regulations so that they are simple and easy to understand, with the goal of minimizing the potential for uncertainty and litigation arising from such uncertainty. Similarly, the Presidential memorandum of June 1, 1998 (63 FR 31883) directs the heads of executive departments and agencies to use, by January 1, 1999, plain language in all proposed and final rulemaking documents published in the **Federal Register**, unless the rule was proposed before that date.

Today's proposed rule uses the following general techniques to abide by Section 1(b)(12) of Executive Order 12866 and the Presidential memorandum of June 1, 1998 (63 FR 31883):

- Organization of the material to serve the needs of the readers (stakeholders).
- Use of common, everyday words.
- Shorter sentences and sections.

We invite your comments on how to make this proposed rule easier to understand.

J. Assessment of Federal Regulations and Policies on Families Review

Section 654 of the Treasury and General Government Appropriations Act, 1999 (Pub. L. No. 105–277) requires Federal agencies to issue a Family Policymaking Assessment for any proposed rule or policy that may affect family well-being. Today's proposal would not have any impact on the autonomy or integrity of the family as an institution. Accordingly, DOE has concluded it is not necessary to prepare a Family Policymaking Assessment.

VI. Public Comment Procedures

A. Written Comment Procedures

The Department invites interested persons to participate in the proposed rulemaking by submitting data, comments, or information with respect to the proposed issues set forth in today's proposed rule to Ms. Brenda Edwards-Jones, at the address indicated at the beginning of this notice. We will consider all submittals received by the date specified at the beginning of this notice in developing the final rule.

According 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 one complete copy of the document and ten (10) copies, if possible, from which the information believed to be confidential has been deleted. The Department of Energy will make its own determination with regard to the confidential status of the information and treat it according to its determination.

Factors of interest to the Department when evaluating requests to treat as confidential information that has been submitted include: (1) A description of the items; (2) an indication as to 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) an indication as to 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.

B. Public Workshop

1. Procedures for Submitting Requests To Speak

You will find the time and place of the public workshop listed at the beginning of this notice of proposed rulemaking. The Department invites any person who has an interest in today's notice of proposed rulemaking, or who is a representative of a group or class of persons that has an interest in these proposed issues, to make a request for an opportunity to make an oral presentation. If you would like to attend the public workshop, please notify Ms. Brenda Edwards-Jones at (202) 586–2945. You may hand deliver requests to speak to the address indicated at the beginning of this notice between the hours of 8:00 a.m. and 4:00 p.m., Monday through Friday, except Federal holidays, or send them by mail.

The person making the request should state why he or she, either individually or as a representative of a group or class of persons, is an appropriate spokesperson, briefly describe the nature of the interest in the rulemaking, and provide a telephone number for contact.

The Department requests each person wishing to speak to submit an advance copy of his or her statement at least ten days prior to the date of this workshop as indicated at the beginning of this notice. The Department, at its discretion, may permit any person wishing to speak who cannot meet this requirement to participate if that person has made alternative arrangements with the Office of Building Research and Standards in advance. The letter making a request to give an oral presentation must ask for such alternative arrangements.

2. Conduct of Workshop

The workshop (hearing) will be conducted in an informal, conference style. The Department may use a professional facilitator to facilitate discussion, and a court reporter will be present to record the transcript of the meeting. We will present summaries of comments received before the workshop, allow time for presentations by workshop participants, and encourage all interested parties to share their views on issues affecting this rulemaking. Following the workshop, we will provide an additional comment period, during which interested parties will have an opportunity to comment on the proceedings at the workshop, as well as on any aspect of the rulemaking proceeding.

The Department will arrange for a transcript of the workshop and will make the entire record of this rulemaking, including the transcript, available for inspection in the Department's Freedom of Information Reading Room. Any person may purchase a copy of the transcript from the transcribing reporter. You can also download the TSD and other analyses from the Internet at: http://www.eren.doe.gov/buildings/codes_standards/applbrf/waterheater.htm

C. Issues for Public Comment

We are interested in receiving comments and data to improve our analyses. In particular, we are interested in seeking responses to the following questions and/or concerns:

1. Gas-fired water heater venting studies or data on venting problems. Data or studies on the use of 80% RE gas-fired water heaters in natural draft venting systems. Data on the number of 78% or 80% RE gas-fired water heaters installations, type of venting systems employed and the length of time installed.

2. The number or type of ''size constrained'' replacement water heater installations. Data on the cost impact of installing a 3–4 inch larger diameter water heater in existing manufactured homes, mobile homes, attics, and applications where water heaters are located in the living space. Also, comments on the number of water heaters affected. Suggestions for alternative technologies such as, higher input gas burners or larger electric heating elements, that may reduce the impact of thicker insulation on ''size constrained'' replacement water heater applications.

3. Additives or blowing agents with zero ozone depletion potential that will

provide lower conductivity or cost than HFC–245fa blown insulation at temperatures between 120°F and 140°F. We also request comment on our choice of insulation blowing agent, among the alternatives we analyzed. We welcome other suggestions of appropriate blowing agents.

4. Approaches that will reduce the impact on manufacturers of the relatively short time between the availability of HFC–245fa in commercial quantities, the phase-out of HCFC–141b and a proposed effective date of September 2003 for DOE's amended water heater energy conservation standard.

5. DOE is considering a consistent distribution of consumer discounts ranging from 4–12% with a mean of 6% for all the appliance products. We would like comments on this approach as it applies to water heaters.

6. We request comments on the validity of the analytical methods used to develop the direct effects of water heater standards on national employment and the appropriate interpretation and use of the results of this analysis approach.

Appendix A—Acronyms and Abbreviations

ACEEE American Council for an Energy Efficiency Economy
ADL Arthur D. Little
AEO EIA's Annual Energy Outlook
AEO99 EIA's 1999 Annual Energy Outlook
AGA America Gas Association
ANOPR Advance Notice of Proposed Rulemaking
ANSI American National Standards Institute
ASHRAE American Society for Heating, Refrigerating and Air-Conditioning Engineers
BRS DOE's Office of Building Research and Standards
Btu British thermal unit
C Elemental carbon
CE Consumer Expenditures
CEC California Energy Commission
CFR Code of Federal Regulations
CNG Connecticut Natural Gas
CO Carbon monoxide
CO_2 Carbon dioxide
CPSC Consumer Product Safety Commission
DOE U.S. Department of Energy (also the Department)
DOJ U.S. Department of Justice
EA Environmental Assessment
EEI Edison Electric Institute
EIA DOE's Energy Information Administration
EERE DOE's Office of Energy Efficiency and Renewable Energy
EF Energy factor
EJ Exajoule
EMPA Energy Market and Policy Analysis
EPA Environmental Protection Agency
EPCA Energy Policy and Conservation Act
EPRI Electric Power Research Institute
FEMP Federal Energy Management Program
FOI Freedom of Information
FONSI Finding of No Significant Impact
FR Federal Register
GAMA Gas Appliance Manufacturers Association
GRI Gas Research Institute
GRIM Government Regulatory Impact Model
HCFC Hydrochlorofluorocarbon
HFC Hydrofluorocarbon
IID Intermittent ignition device
ImBuild Impact of Building Energy Efficiency Programs model
INPV Industry net present value
ITS Intertek Testing Services
kt Thousand metric tons
kWh kilowatt hours
LBNL Lawrence Berkeley National Laboratory
LCC Life-cycle cost
LPG Liquid petroleum gas
MIA Manufacturer impact analysis
MMBtu Million Btus
Mt Million metric tons
NEEA Northwest Energy Efficiency Alliance
NEGA New England Gas Association
NEMS National Energy Modeling System
NEMS–BRS National Energy Modeling System—Building Research and Standards
NEPA National Environmental Policy Act
NES National energy savings
NFGC National Fuel Gas Code
NGC Natural Gas Council
NIST National Institute of Standards and Technology
NO_X Oxides of nitrogen
NOAA National Oceanic and Atmospheric Administration
NOPR Notice of Proposed Rulemaking
NPV Net present value
NRDC Natural Resources Defense Council
NRECA National Rural Electric Cooperative Association
NU Northeast Utilities
NWPPC Northwest Power Planning Council
OIRA Office of Information and Regulatory Affairs
OOE Oregon Office of Energy
ORNL Oak Ridge National Laboratory
PG&E Pacific Gas and Electric
PNNL Pacific Northwest National Laboratory
Pon Rated input power
RE Recovery efficiency
RECS Residential Energy Consumption Survey
RIA Regulatory impact analysis
SC Southern Company
SO_2 Sulfur dioxide
TANK Computer simulation model for gas-fired water heaters
TSD Technical Support Document
UA Heat transfer coefficient
UMRA Unfunded Mandates Reform Act of 1995
VOC Volatile organic compound
VP Virginia Power
WATSIM Computer simulation model for electric storage water heaters
WHAM Water Heater Analysis Model for oil-fired water heaters

List of Subjects in 10 CFR Part 430

Administrative practice and procedure, Energy Conservation, Household appliances.

Issued in Washington, DC, on March 8, 2000.

Dan W. Reicher,

Assistant Secretary, Energy Efficiency and Renewable Energy.

For the reasons set forth in the preamble, Part 430 of Chapter II of Title 10, Code of Federal Regulations is proposed to be amended as set forth below.

PART 430—ENERGY CONSERVATION PROGRAM FOR CONSUMER PRODUCTS

1. The authority citation for Part 430 continues to read as follows:

Authority: 42 U.S.C. 6291–6309.

2. Section 430.32(d) of Subpart C is revised to read as follows:

§ 430.32 Energy conservation standards and effective dates.

* * * * *

(d) Water Heaters

The energy factor of water heaters shall not be less than the following for products manufactured on or after the indicated dates.

Product class	Energy factor as of January 1, 1990	Energy factor as of April 15, 1991	Energy factor as of [date 3 years from publication of final rule]
1. Gas-fired Water Heater	0.62 − (.0019 × Rated Storage Volume in gallons).	0.62 − (.0019 × Rated Storage Volume in gallons).	0.67 − (0.0019 × Rated Storage Volume in gallons).
2. Oil-fired Water Heater	0.59 − (.0019 × Rated Storage Volume in gallons).	0.59 − (.0019 × Rated Storage Volume in gallons).	0.59 − (0.0019 × Rated Storage Volume in gallons).
3. Electric Water Heater	0.95 − (.00132 × Rated Storage Volume in gallons).	0.93 − (.00132 × Rated Storage Volume in gallons).	0.97 − (0.00132 × Rated Storage Volume in gallons).

Note: The Rated Storage Volume equals the water storage capacity of a water heater, in gallons, as specified by the manufacturer.

* * * * *

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