CHAPTER 2. ANALYTICAL FRAMEWORK

TABLE OF CONTENTS

CHAPTER 2. ANALYTICAL FRAMEWORK

2.1 INTRODUCTION

Section 6295(o)(2)(A) of Chapter 42 of the United States Code (U.S.C.) requires that the U.S. Department of Energy (DOE), when prescribing new or amended energy conservation standards, promulgate standards that achieve the maximum improvement in energy efficiency that DOE determines is both technologically feasible and economically justified. This chapter provides a description of the general analytical framework that DOE uses in developing such standards, and in particular, amended energy conservation standards for residential water heaters, direct heating equipment, and pool heaters. The analytical framework is a description of the methodology, the analytical tools, and relationships among the various analyses that are part of this rulemaking. For example, the methodology that addresses the statutory requirement for economic justification includes analyses of life-cycle cost (LCC); economic impact on manufacturers and users; national benefits; impacts, if any, on utility companies; and impacts, if any, from lessening competition among manufacturers. DOE will also solicit the views of the Department of Justice (DOJ) on any lessening of competition likely to result from the imposition of a proposed standard.

Figure 2.1.1 summarizes the analytical components of the standards-setting process. The focus of this figure is the center column, identified as “Analyses.” The columns labeled “Key Inputs” and “Key Outputs” show how the analyses fit into the rulemaking process, and how the analyses relate to each other. Key inputs are the types of data and information that the analyses require. Some key inputs exist in public databases; DOE collects other inputs from stakeholders or persons with special knowledge. Key outputs are analytical results that feed directly into the standards-setting process. Arrows connecting analyses show types of information that feed from one analysis to another.

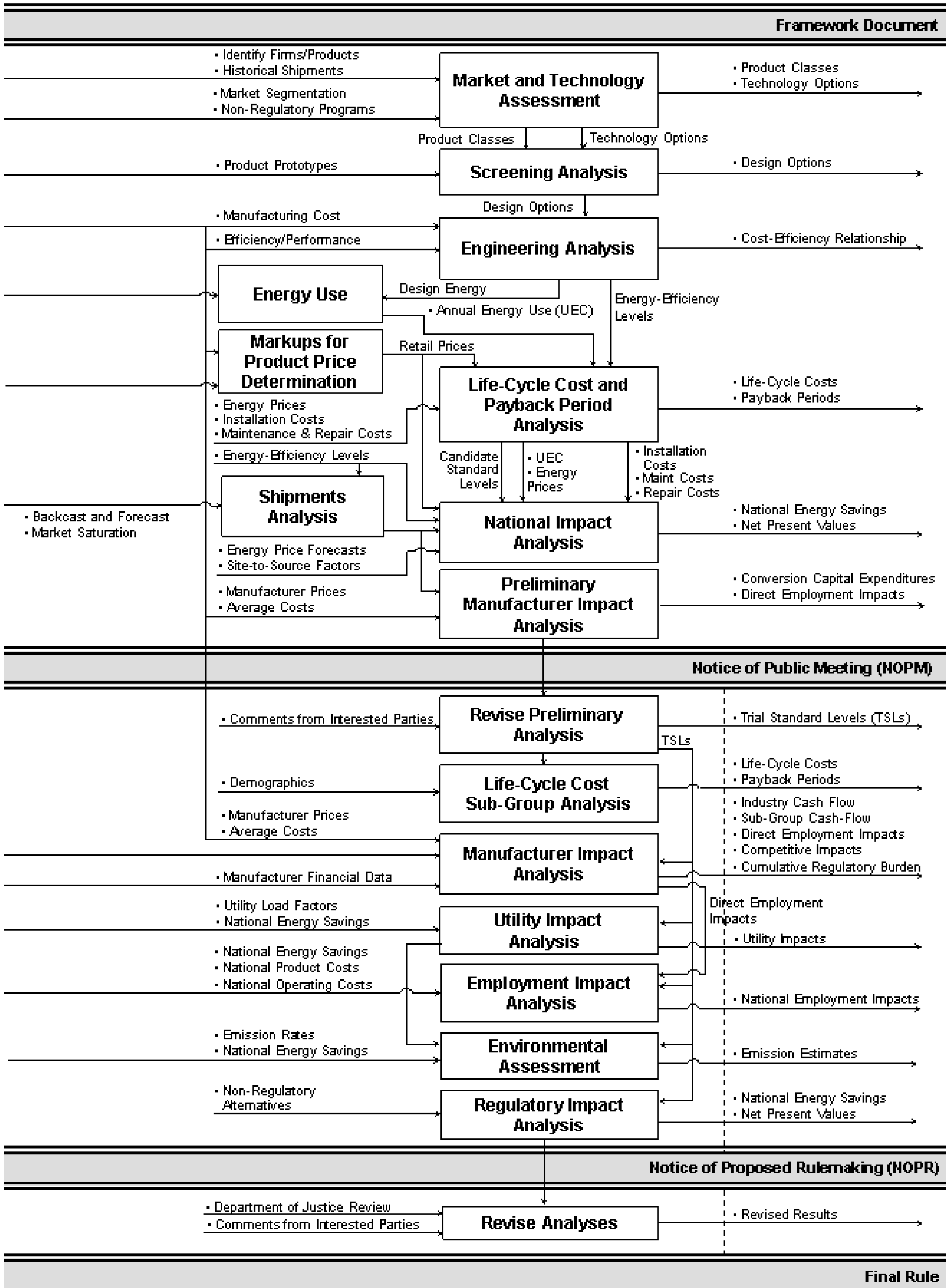

Figure 2.1.1 Flow Diagram of Analyses for the Residential Heating Products Rulemaking Process

The analyses performed prior to the notice of proposed rulemaking (NOPR) stage as part of the preliminary analyses and described in the preliminary technical support document (TSD) are listed below. These analyses were revised for the NOPR based on new information from comments received, and are reported in the NOPR TSD. The analyses were revised once again for the final rule based on any new comments or data received in response to the NOPR, and are reported in this TSD (the final rule TSD).

- A market and technology assessment to characterize the relevant product markets and existing technology options, including prototype designs.

- A screening analysis to review each technology option and determine if it is technologically feasible; is practical to manufacture, install, and service; would adversely affect product utility or product availability; or would have adverse impacts on health and safety.

- An engineering analysis to develop cost-efficiency relationships that show the manufacturer's cost of achieving increased efficiency. DOE determines the increased cost to the consumer through an analysis of engineering markups, which convert manufacturer production cost (MPC) to manufacturer selling price (MSP).

- An energy use analysis to determine the annual energy use in the field of the considered products.

- An LCC and payback period (PBP) analyses to calculate, at the consumer level, the discounted savings in operating costs throughout the estimated average life of the covered products, compared to any increase in the installed cost for the products likely to result directly from imposition of the standard.

- A shipments analysis to forecast product shipments, which then are used to calculate the national impacts of standards and future manufacturer cash flows.

- A national impact analysis (NIA) to assess the aggregate impacts at the national level of potential energy conservation standards for each of the considered products, as measured by the net present value (NPV) of total consumer economic impacts and the national energy savings (NES).

- A preliminary manufacturer impact analysis to assess the potential impacts of energy conservation standards on manufacturers, such as impacts on capital conversion expenditures, marketing costs, shipments, and research and development costs.

The additional analyses DOE performed for the NOPR stage of the rulemaking analysis include those listed below. DOE further revised the analyses for the final rule based on comments received in response to the NOPR.

- An LCC subgroup analysis to evaluate variations in customer characteristics that might cause a standard to affect particular consumer sub-populations, such as low-income households, differently than the overall population.

- A manufacturer impact analysis to estimate the financial impact of standards on manufacturers and to calculate impacts on competition, employment, and manufacturing capacity.

- A utility impact analysis to estimate the effects of proposed standards on electric, gas, or oil utilities.

- An employment impact analysis to assess the aggregate impacts on national employment.

- An environmental impact analysis to provide estimates of the effects of amended energy conservation standards on three pollutants—sulfur dioxide (SO_2), nitrogen oxides (NO_X), and mercury—as well as carbon emissions.

- A regulatory impact analysis to present major alternatives to proposed amended energy conservation standards that could achieve substantially the same regulatory goal at a lower cost.

2.2 BACKGROUND

DOE developed this analytical framework and documented its findings in the Rulemaking Framework for Residential Water Heaters, Direct Heating Equipment, and Pool Heaters (September 27, 2006). DOE announced the availability of the framework document in a notice of public meeting and availability of a framework document published in the *Federal Register* on November 24, 2006. 71 FR 67825. DOE presented the analytical approach to interested parties during a public meeting held on January 16, 2007. The framework document is available at www1.eere.energy.gov/buildings/appliance_standards/residential/pdfs/heating_equipment_framework_092706.pdf.

DOE conducted a preliminary analysis for residential heating products and documented its findings in the preliminary TSD (January 5, 2009). The preliminary TSD is available at www1.eere.energy.gov/buildings/appliance_standards/residential/water_pool_heaters_nopm.html. In response to the publication of the framework document and the framework public meeting, DOE received numerous comments from interested parties regarding DOE’s analytical approach. For a summary of the key comments DOE received from interested parties and DOE’s responses to those comments, see chapter 2 of the preliminary TSD.

In support of the NOPR for residential heating products, DOE revised the preliminary analysis and performed several new analyses, which are documented the NOPR analysis in the NOPR TSD (November 23, 2009). The NOPR TSD describes in detail the revisions made to the preliminary analysis for the NOPR phase, as well as the several new analyses that were performed for the NOPR. The NOPR TSD is available at http://www1.eere.energy.gov/buildings/appliance_standards/residential/water_pool_heaters_nopr_tsd.html.

The following sections provide a general description of the different analytical components of the rulemaking analytical plan. DOE has used the most reliable data available at the time of each analysis in this rulemaking. DOE has also considered submissions of additional data from interested parties during the rulemaking process.

2.3 MARKET AND TECHNOLOGY ASSESSMENT

The market and technology assessment (chapter 3) characterizes the relevant residential water heater, direct heating equipment, and pool heater markets and existing technology options, including prototype designs.

2.3.1 Market Assessment

When initiating a standards rulemaking, DOE develops information on the present and past industry structure and market characteristics for the equipment concerned. This activity assesses the industry and equipment both quantitatively and qualitatively based on publicly available information and encompasses the following: (1) manufacturer market share and characteristics; (2) existing regulatory and non-regulatory equipment efficiency improvement initiatives; and (3) trends in product characteristics and retail markets. This information serves as resource material throughout the rulemaking.

DOE reviewed existing literature and interviewed manufacturers to get an overall picture of the residential water heater, direct heating equipment, and pool heater industry in the United States. Industry publications and trade journals, government agencies, and trade organizations provided the bulk of the information, including: (1) manufacturers and their approximate market shares; (2) shipments by capacity and equipment class; (3) equipment information; and (4) industry trends. The appropriate sections of the final rule describe the analysis and resulting information leading up to the final standard level, while the supporting documentation is provided in the different chapters of the TSD.

2.3.2 Product Classes

DOE categorized the product types (*i.e.*, residential water heaters, residential direct heating equipment, and pool heaters) into product classes formulated a separate energy conservation standard for each product class. The criteria for separation into different classes are type of energy used, capacity, and other performance-related features such as those that provide utility to the consumer or others deemed appropriate by the Secretary that would justify the establishment of a separate energy conservation standard. (42 U.S.C. 6295(q) and 6316(a))

For residential water heaters, the product classes are based on energy source (*i.e.*, gas or electric) and design (*i.e.*, storage-type, tabletop, and instantaneous or "tankless"). The product classes for residential water heaters were established by the January 17, 2001, Energy Conservation Standards for Water Heaters; Final Rule (the January 2001 final rule) amending the energy conservation standards for residential water heaters and incorporated into section 430.32(d). 66 FR 4474, 4497 (January 17, 2001).

The National Appliance Energy Conservation Act (NAECA) establishes product classes for direct heating equipment (42 U.S.C. 6295(e)(3)) However, DOE has reduced the number of heating capacity ranges for direct heating equipment to better reflect the distribution of direct heating equipment available on the market. In addition, DOE has added separate product class of direct heating equipment – gas vented hearth products.

For pool heaters, the only product class is gas-fired pool heaters, which was established by NAECA. (42 U.S.C. 6295(e)(2)) A full discussion of the product classes for residential heating products can be found in chapter 3 of the final rule TSD.

2.3.3 Technology Assessment

As part of the market and technology assessment, DOE developed a list of technologies for consideration for improving the efficiency of residential water heaters, direct heating equipment, and pool heaters. DOE typically uses information about existing and past technology options and prototype designs to determine which technologies manufacturers use to attain higher performance levels. In consultation with interested parties, DOE develops a list of technologies for consideration. Initially, these technologies encompass all those DOE believes are technologically feasible.

DOE developed its list of technologically feasible design options for each of the three products from trade publications and technical papers and through consultation with manufacturers of components and systems. Since many options for improving product efficiency are available in existing products, product literature and direct examination of products on the market provided additional information.

DOE removed technology options whose energy consumption could not be adequately measured by the existing DOE test procedure. DOE also removed technologies that do not change or affect the energy efficiency metrics of water heaters, direct heating equipment, and pool heaters before moving on to the screening analysis. Chapter 3 of the final rule TSD includes the detailed list of all technology options identified for residential water heaters, direct heating equipment, and pool heaters.

2.4 SCREENING ANALYSIS

After DOE identified the technologies in the technology assessment that could potentially improve the energy efficiency of residential heating products, DOE conducted the screening analysis. The purpose of the screening analysis is to evaluate the technologies to determine which options to consider further and which options to screen out. DOE consults with industry, technical experts, and other interested parties in developing a list of technologies for consideration. DOE then applies the screening criteria to determine which technologies are unsuitable for further consideration in this rulemaking. Chapter 4 of the final rule TSD, the screening analysis, contains details on the criteria that DOE uses.

The screening analysis examines whether various technologies (1) are technologically feasible; (2) are practicable to manufacture, install, and service; (3) have an adverse impact on product utility or availability; and (4) have adverse impacts on health and safety. In consultation with interested parties, DOE reviews the list to determine if the technologies described in chapter 3 of the final rule TSD are practicable to manufacture, install, and service; would adversely affect product utility or availability; or would have adverse impacts on health and safety. In the engineering analysis, DOE further considers the efficiency-enhancement options (*i.e.*, technologies) that it did not screen out in the screening analysis.

2.5 ENGINEERING ANALYSIS

The engineering analysis (chapter 5) establishes the relationship between the manufacturing production cost (MPC) and the efficiency for each residential heating product. This relationship serves as the basis for cost/benefit calculations in terms of individual consumers, manufacturers, and the Nation. Chapter 5 discusses product classes DOE analyzed, the representative baseline units, the efficiency levels analyzed, the methodology DOE used to develop the manufacturing production costs, the cost-efficiency curves, the impact of efficiency improvements on the considered products, and the methodology DOE used to extend the analysis to other products that were not explicitly analyzed.

In the engineering analysis, DOE evaluates a range of product efficiency levels and their associated manufacturing costs. The purpose of the analysis is to estimate the incremental manufacturer selling prices (MSPs) for a product that would result from increasing efficiency levels above the level of the baseline model in each product class. The engineering analysis considers technologies not eliminated in the screening analysis. The LCC analysis uses the cost-efficiency relationships developed in the engineering analysis.

DOE typically structures its engineering analysis around one of three methodologies: (1) the design-option approach, which calculates the incremental costs of adding specific design options to a baseline model; (2) the efficiency-level approach, which calculates the relative costs of achieving increases in energy efficiency levels without regard to the particular design options used to achieve such increases; and/or (3) the reverse-engineering or cost-assessment approach, which involves a "bottom-up" manufacturing cost assessment based on a detailed bill of materials derived from tear-downs of the product being analyzed.

For the residential heating products engineering analysis, DOE used both the efficiency level approach to identify incremental improvements in efficiency for each product and the cost-assessment approach to develop a cost for each efficiency level. This approach involved physically disassembling commercially available products, consulting with outside experts, reviewing publicly available cost and performance information, and modeling equipment cost. Most of the efficiency levels that DOE considered in the engineering analysis are attainable by using technologies currently available on the market and commonly incorporated into residential heating products by manufacturers. All of the efficiency levels are achievable using technologies that have been demonstrated either in commercially available products or prototypes. In addition, DOE associated each efficiency level with a specific technology to provide interested parties with additional transparency of assumptions and results, and the ability to perform independent analyses for verification. Chapter 5 of the final rule TSD describes the methodology that DOE used to perform the efficiency level analysis and derive the cost-efficiency relationship.

2.5.1 Product Classes Analyzed

The engineering analysis directly analyzed all product classes covered in this rulemaking. However, due to the wide range of storage volumes for storage water heaters and input capacities for other covered products, not all volume and capacity ranges were directly analyzed in the engineering analysis and the subsequent analyses. The market data presented in the market and technology assessment (chapter 3) was used to prioritize covered products to be analyzed based on either storage volume or input capacity. DOE defined four product classes of water heaters, five product classes of direct heating equipment, and one product class of pool heaters for this rulemaking. For storage water heaters, DOE focused its analysis on one representative storage volume for each product class. However, DOE also examined products at several discreet rated storage volumes above and below the representative storage volumes. For instantaneous gas-fired water heaters, the five classes of direct heating equipment, and pool heaters, DOE analyzed a representative input capacity or an input capacity range for each product class. DOE then extended the analysis of the representative product classes to the entire range of products covered. A description of the representative products analyzed and the methodology for extending the analysis to other product sizes can be found in chapter 5 of the final rule TSD.

2.5.2 Cost Assessment

The manufacturing cost assessment estimated the manufacturing costs associated with residential heating products at various efficiency levels, including baseline, intermediate, and max-tech levels. The purpose of the cost assessment is to estimate the cost of increasing the energy efficiency for each type of the residential heating products. The approach involved selecting representative products, disassembling specific units, analyzing the materials and manufacturing processes used to manufacture those units, and developing a cost model spreadsheet that allowed DOE to convert the material and manufacturing processes into the manufacturer production cost. DOE developed a detailed manufacturing cost assessment model that estimates manufacturer production cost, reports the manufacturer production costs in aggregated form to maintain confidentiality of the data, and incorporates input from stakeholders on the manufacturer production cost estimates and assumptions. After assessing the manufacturer production cost using the cost model, DOE developed manufacturer markups to establish the MSP for products at each efficiency level. More detail on the MPCs and MSPs is available in chapter 5 of the final rule TSD.

2.5.3 Energy-Efficiency Equations for Water Heaters

As part of the engineering analysis for residential water heaters, DOE also reviewed the energy-efficiency equations that define the existing Federal energy conservation standards for gas-fired and electric storage water heaters. In particular, DOE reviewed the relationship between energy factor (EF) and rated storage volume. DOE also investigated alternative energy-efficiency equations to define amended energy conservation standards. See chapter 5 of the final rule TSD for more information on the representative rated storage volumes, the efficiency levels analyzed, the relationship of the current market to the current energy conservation standards, and the relationship between EF and rated storage volume.

2.6 MARKUPS TO DETERMINE PRODUCT PRICE

DOE used manufacturer-to-consumer markups to convert the manufacturer selling prices estimated in the engineering analysis to customer prices, which then were used in the LCC, PBP, and manufacturer impact analyses. DOE calculates markups for baseline products (baseline markups) and for more efficient products (incremental markups) based on the markups at each step in the distribution channel. The overall incremental markup relates the change in the manufacturer sales price of higher-efficiency models (the incremental cost increase) to the change in the retailer or distributor sales price.

In order to develop markups, DOE identifies how the products are distributed from the manufacturer to the customer (the distribution channels). DOE estimated manufacturer-to-customer markups for residential heating products based on separate distribution channels for water heaters, direct heating equipment, and pool heaters. After establishing appropriate distribution channels for each of the product classes, DOE relied on economic data from the U.S. Census Bureau and other sources to define how prices are marked up as the products pass from the manufacturer to the customer. A detailed description of the distribution channels and the markup applied at each step in the distribution process can be found in chapter 6 of the final rule TSD.

2.7 ENERGY USE CHARACTERIZATION

The energy use characterization, which assesses the energy savings potential from adopting higher efficiency standards, provides the basis for the energy savings values used in the LCC and subsequent analyses. DOE calculated the energy savings for each heating product class compared to baseline models. As part of the characterization, DOE made certain engineering assumptions regarding product application, including how the products are operated and under what conditions. Those assumptions are documented in chapter 7 of the final rule TSD, which also provides more detail about DOE's approach.

2.7.1 Water Heaters

For residential storage-type water heaters, DOE relied on an energy use analysis tool, the water heater analysis model, and a hot water draw model. For this rulemaking, DOE modified earlier versions of the tools, which were used to conduct the previous rulemaking that concluded in 2001. Combined with data from the Energy Information Administration's (EIA's) 2005 Residential Energy Consumption Survey (RECS), these analysis tools enable DOE to establish the variation in water heater energy consumption in the United States.

DOE determined the annual energy consumption of water heaters in actual housing units by considering the primary factors that determine energy use: hot water use per household, the energy efficiency characteristics of the water heater, and water heater operating conditions other than hot water draws. DOE used a hot water draw model to determine hot water use for each household in the sample. The characteristics of each water heater's energy efficiency were taken from the engineering analysis. DOE developed water heater operating conditions (other than hot water draws) from weather data and other relevant sources. DOE calculated the energy use of water heaters using a simplified energy equation, the water heater analysis model (WHAM), which accounts for a range of operating conditions and energy efficiency characteristics of water heaters.

For heat pump water heaters, DOE investigated the issue of overcooling of the indoor space. To account for these indirect effects on home heating (and cooling), DOE estimated the impact on energy consumption for space heating and air conditioning for each home in the RECS subsample of homes containing electric water heaters with the water heater located in the conditioned space.

To analyze gas-fired instantaneous water heaters, DOE modified the approach used for storage water heaters to account for the absence of a storage tank. DOE applied a performance adjustment factor to account for evidence that the rated energy efficiency of instantaneous water heaters does not accurately portray actual performance. DOE used a performance adjustment factor for gas-fired instantaneous water heater field energy use that varies with the household hot water consumption.

2.7.2 Direct Heating Equipment and Pool Heaters

To represent actual households likely to purchase and use direct heating equipment, DOE developed a household sample from RECS 2005. The sample comprises units that used a floor/wall furnace, fireplace, or heater as the primary or secondary source of heat. DOE believes that the sample size for direct heating equipment is large enough to provide representative data on the conditions under which U.S. households use such products.

For households for which it is evident that the natural gas used for heating is associated solely with using the direct heating equipment as the primary or secondary heat source, DOE used the household's annual fuel consumption for heating from RECS 2005. For households that used a gas furnace as the primary heating equipment and direct heating equipment as a secondary heat source, DOE adjusted the house heating load to estimate the energy use of the direct heating equipment. RECS reports the fraction of heating energy consumed by the secondary products. DOE reduced the house heating load ascribable to direct heating equipment by subtracting the estimated amount of heat provided by the secondary system.

To represent actual households likely to purchase and use pool heaters, DOE developed a household sample from RECS 2005. Although the RECS sample for pool heaters is relatively small, DOE believes that it is the best available source for estimates of pool heater energy use in the field. To account for the different energy use characteristics of residential pool and spa heaters, DOE used a distribution of values for operating hours that encompasses a wide range of situations, including those with and without spa heating. DOE did not separately analyze energy usage for pool heaters and spa heaters.

DOE relied on the assumptions in the DOE test procedures to establish the typical annual energy consumption of direct heating equipment and pool heaters. However, DOE did modify some of the assumptions to better reflect actual operating conditions. For direct heating equipment, DOE used home heating loads derived from RECS instead of the average assumptions in the test procedure. For pool heaters, DOE used pool heater heating loads derived from RECS instead of the average test procedure assumptions.

2.8 LIFE-CYCLE COST AND PAYBACK PERIOD ANALYSES

New energy conservation standards affect products' operating expenses—usually decreasing them—and consumer prices for the products—usually increasing them. DOE analyzed the net effect of amended standards on consumers by evaluating the net LCC. To evaluate the net LCC, DOE used the cost-efficiency relationship derived in the engineering analysis, along with the energy costs derived from the energy use characterization. Inputs to the LCC calculation include the installed cost of a product to the consumer (consumer purchase price plus installation cost), operating expenses (energy expenses and maintenance and repair costs), the lifetime of the unit, and a discount rate.

Because the installed cost of a product typically increases while operating cost typically decreases in response to new standards, there is a time in the life of products having higher-than-baseline efficiency when the net operating-cost benefit (in dollars) since the time of purchase is equal to the incremental first cost of purchasing the higher-efficiency product. The length of time required for products to reach this cost-equivalence point is known as the payback period (PBP).

DOE conducted the LCC and PBP analyses using typical values to reflect energy consumption in the field. DOE identified several input values for estimating the LCC, including retail prices; electricity prices; discount rate; maintenance, repair, and installation costs; and product lifetimes. Chapter 8 of the final rule TSD provides more detail about DOE's approach.

DOE used EIA's energy price data to determine recent prices of electricity, natural gas, oil, and liquefied petroleum gas. DOE used projections of those energy prices from EIA's Annual Energy Outlook (AEO) 2010 to estimate future energy prices. In calculating energy consumption, DOE considered the rebound effect (also called a take-back effect, or offsetting behavior), which refers to the increased energy consumption resulting from actions that increase energy efficiency and reduce consumer costs. The rebound effect assumes that consumers give up some of the potential energy savings to receive more service. To determine how the rebound effect may impact the energy savings for the considered heating products, DOE searched the literature on the rebound effect. DOE also considered how the National Energy Modeling system (NEMS), which is used for developing EIA's AEO, incorporates a rebound effect. Based on available information, DOE used a rebound effect of 10 percent for water heaters, 15 percent for direct heating equipment, and 10 percent for pool heaters. For more detail on the rebound effect, see chapter 8 of the final rule TSD.

DOE developed discount rates from estimates of the interest rate, or finance cost, applied to purchases of residential products. Following accepted principles of financial theory, the finance cost of raising funds to purchase such products can be interpreted as: (1) the financial cost of any debt incurred to purchase products, principally interest charges on debt; or (2) the opportunity cost of any equity used to purchase products, principally interest earnings on household equity.

DOE considered expected changes to maintenance, repair, and installation costs for the products covered in this rulemaking. The installation costs for residential heating products depend largely on the products' electrical power and venting requirements. Typically, small incremental changes in product efficiency produce no, or only minor changes in repair and maintenance costs over baseline efficiency products. Products having efficiencies that are significantly greater than baseline efficiencies can incur increased repair and maintenance costs because they are more likely to incorporate technologies that are more advanced.

DOE used information from various published literature sources as well as input from manufacturers and other stakeholders to establish distributions of product lifetimes for use in the life-cycle cost and subsequent analyses.

2.9 SHIPMENTS ANALYSIS

Forecasts of product shipments are needed to calculate the national impacts of standards on energy use, NPV, and future manufacturer cash flows. DOE developed shipment forecasts based on an analysis of key market drivers for each considered product. The shipments models take an accounting approach, tracking market shares of each product class and the vintage of units in the existing stock. Stock accounting uses product shipments as inputs to estimate the age distribution of in-service product stocks for all years. The age distribution of in-service product stocks is a key input to calculations of both the NES and NPV, because operating costs for any year depend on the age distribution of the stock.

DOE evaluated the potential for energy conservation standards to induce product switching, especially for water heaters. In particular, DOE examined the potential for switching from a heat pump electric storage water heater to a gas-fired water heater. DOE used data from the 2005 RECS to estimate the percentage of households expected to purchase an electric water heater in the base case that could switch to a gas-fired water heater. To estimate how many of the households that could switch to gas-fired water heaters would do so, DOE considered the difference in installed cost between a gas-fired storage water heater and an electric heat pump water heater for different gas water heater designs.

Chapter 9 of the final rule TSD provides additional details on the shipments analysis.

2.10 NATIONAL IMPACT ANALYSIS

The national impact analysis assesses the aggregate impacts at the national level of potential energy conservation standards for each of the considered products, as measured by the net present value (NPV) of total consumer economic impacts and the national energy savings (NES). DOE determined both the NPV and NES for the performance levels considered for the product classes analyzed. To make the analysis more accessible and transparent to all interested parties, DOE prepared a Microsoft Excel spreadsheet model to forecast NES and the national consumer economic costs and savings resulting from new standards. The spreadsheet model uses as inputs typical values (as opposed to probability distributions). To assess the effect of input uncertainty on NES and NPV results, DOE conducted sensitivity analyses by running scenarios on specific input variables, which are described in chapter 10 of the final rule TSD.

2.10.1 National Energy Savings Analysis

The inputs for determining the national energy savings (NES) for each product analyzed are: (1) annual energy consumption per unit; (2) shipments; (3) product stock; (4) national energy consumption; and (5) site-to-source conversion factors. DOE calculated the national energy consumption by multiplying the number of units, or stock, of each product (by vintage) by the unit energy consumption (also by vintage).[a] DOE calculated annual NES based on the difference in national energy consumption for the base case (without new efficiency standards) and for each higher efficiency standard. DOE estimated energy consumption and savings based on site energy, and converted the electricity consumption and savings to source energy. Cumulative energy savings are the sum of the NES for each year.

The stock of a product is dependent on annual shipments and the lifetime of the product. DOE projected shipments under the base efficiency case and higher efficiency standards cases for various product efficiency scenarios and product efficiency trends. DOE's shipments model

[a] Vintage represents the age of the product.

assumed that shipments of new products are driven by new construction as well as stock replacements.

2.10.2 Net Present Value Analysis

The inputs for determining net present value (NPV) are: (1) total annual installed cost; (2) total annual savings in operating costs; (3) a discount factor; (4) present value of costs; and (5) present value of savings. DOE calculated net savings each year as the difference between the base case and each standards case in total savings in operating costs and total increases in installed costs. DOE calculated savings over the life of each product, accounting for differences in yearly energy rates. DOE calculated NPV as the difference between the present value of operating cost savings and the present value of total installed costs. DOE used a discount factor to discount future costs and savings to present values.

DOE calculated increases in total installed costs as the product of the difference in total installed cost between the base case and standards case (*i.e.*, once the standards take effect). Because the more efficient products bought in the standards case usually cost more than products bought in the base case, cost increases appear as negative values in the NPV.

DOE expressed savings in operating costs as decreases associated with the lower energy consumption of products bought in the standards case compared to the base efficiency case. Total savings in operating costs are the product of savings per unit and the number of units of each vintage that survive in a given year.

2.10.3 Efficiency Scenarios and Trends

Several of the inputs for determining NES and NPV depend on the product efficiency. DOE developed efficiency trends for the base case and standards cases. These trends specify the average annual historical and forecasted shipments-weighted product efficiencies.

DOE used data from industry sources to develop average shipments-weighted efficiency trends for the considered products. After establishing efficiency trends, DOE derived annual energy consumption based on relationships between efficiency and unit energy consumption.

DOE used a roll-up efficiency scenario in developing its forecasts of efficiency trends after standards take effect. Under a roll-up scenario, all products that perform at levels below a prospective standard are moved, or rolled-up, to the minimum performance level allowed under the standard. The distribution of products that meet the higher efficiency standard levels is unaffected.

2.10.4 Impact of Standards on Natural Gas Prices and Overall Economic Benefits

The national impacts analysis examines the potential economic impacts of alternative standard levels on consumers who purchase the considered products. To evaluate potentially important indirect effects of energy conservation standards on energy users in general, DOE analyzed the potential impacts of amended standards on natural gas prices and the associated benefits for all natural gas consumers in all sectors of the economy.

DOE considered two scenarios for standards. The max-NPV scenario consists of standards that reflect the energy efficiency levels found to have the greatest consumer NPV. The max-tech scenario encompasses standards that reflect the identified max-tech energy efficiency levels. The max-tech scenario represents the upper bound for impacts on natural gas prices.

DOE's analysis used a variant of the modeling program NEMS, known as NEMS-BT, which has been modified to account for the natural gas savings associated with possible standards. Like other widely used energy-economic models, NEMS incorporates parameters to estimate the changes in energy prices that would result from an increase or decrease in energy demand. The response of price to a decrease in demand is termed the "inverse price elasticity." The overall inverse price elasticity observed in NEMS changes over the forecast period based on the model's dynamics of natural gas supply and demand.

2.11 MANUFACTURER IMPACT ANALYSIS

DOE performed a manufacturer impact analysis (MIA) to estimate the financial impact of higher energy conservation standards on manufacturers of the three heating products, and to calculate the impact of such standards on employment and manufacturing capacity. The MIA has both quantitative and qualitative aspects. The quantitative part of the MIA relies on the government regulatory impact model (GRIM), an industry-cash-flow model customized for these three industries. The GRIM inputs are information regarding the industry cost structure, shipments, and revenues. This includes information from many of the analyses described above, such as manufacturing costs and prices from the engineering analysis and shipments forecasts. The key GRIM output is the industry net present value (INPV). Different sets of assumptions (scenarios) will produce different results. The qualitative part of the MIA addresses factors such as equipment characteristics, characteristics of particular firms, and market and equipment trends, and includes assessment of the impacts of standards on subgroups of manufacturers. The complete MIA is described in chapter 12 of the final rule TSD.

DOE conducted the MIA in this rulemaking in three phases. In Phase I, DOE created an industry profile to characterize the industry and identify important issues that require consideration. In Phase II, DOE prepared an industry cash-flow model and an interview questionnaire to guide subsequent discussions. In Phase III, DOE interviewed manufacturers, and assessed the impacts of standards both quantitatively and qualitatively. DOE assessed industry and subgroup cash flow and NPV using the GRIM. DOE then assessed impacts on competition, manufacturing capacity, employment, and regulatory burden based on manufacturer interview feedback and discussions.

2.12 LIFE-CYCLE COST SUBGROUP ANALYSIS

The LCC subgroup analysis evaluates economic impacts on selected groups of consumers who might be adversely affected by a change in the national energy conservation standards for the considered products. DOE evaluates impacts on particular subgroups of consumers in part by analyzing the LCC impacts and PBP for those particular consumers.

DOE used the LCC spreadsheet model to evaluate impacts on consumer subgroups. DOE can analyze the LCC for any subgroup by applying the LCC spreadsheet model to only that subgroup. DOE is particularly sensitive to increases in the consumer price of the considered products, wishing to avoid a negative economic impact on any identified consumer subgroup.

2.13 UTILITY IMPACT ANALYSIS

The utility impact analysis included an analysis of the effect of new energy conservation standards on the electric and the gas utility industries. For this analysis, DOE adapted NEMS, which is a large multi-sectoral, partial-equilibrium model of the U.S. energy sector that the EIA has developed throughout the past decade, primarily for preparing EIA's AEO. In previous rulemakings, a variant of NEMS (currently termed NEMS-BT, BT referring to DOE's Building Technologies Program), was developed to better address the specific impacts of an energy conservation standard.

NEMS, which is available in the public domain, produces a widely recognized baseline energy forecast for the United States through the year 2030. The typical NEMS outputs include forecasts of electricity sales, prices, and electric generating capacity. DOE conducts the utility impact analysis as a scenario that departs from the latest AEO reference case. In other words, the energy savings impacts from amended energy conservation standards are modeled using NEMS-BT to generate forecasts that deviate from the AEO reference case.

2.14 ENVIRONMENTAL IMPACT ANALYSIS

The intent of the environmental assessment (EA) is to quantify and consider the environmental effects of amended energy conservation standards. The primary environmental effects of energy conservation standards for heating products would be reduced power plant emissions resulting from reduced consumption of electricity. DOE assessed these environmental effects by using NEMS-BT. The portion of the environmental assessment produced by NEMS-BT considers carbon dioxide (CO_2), nitrogen oxides (NO_X), and mercury (Hg). The environmental assessment also considers impacts on SO_2 emissions.

NEMS-BT is run similarly to the AEO NEMS, except that heating product energy use is reduced by the amount of energy saved (by fuel type) due to each TSL. The inputs of national energy savings come from the NIA spreadsheet model; the output is the forecasted physical emissions at each TSL. The net benefit of the standard is the difference between emissions estimated by NEMS-BT at each TSL and the AEO Reference Case. NEMS-BT tracks CO_2 emissions using a detailed module that provides results with broad coverage of all sectors and inclusion of interactive effects. For the final rule, DOE used the *AEO 2009* version of NEMS-BT.

DOE's assessment accounts for existing regulations that affect emissions of the considered pollutants and CO_2. The EA does not include the estimated reduction in power sector emissions of SO_2, because DOE has preliminarily determined that due to the presence of national caps on SO_2 emissions, any reduction in electricity generation resulting from an energy conservation standard would not affect the overall level of SO_2 emissions in the United States.

Future emissions of NO_X were made subject to emissions caps under the Clean Air Interstate Rule (CAIR) issued by the U.S. Environmental Protection Agency on March 10, 2005. 70 FR 25162 (May 12, 2005). CAIR permanently capped emissions in 28 eastern States and the District of Columbia (D.C.). The CAIR was vacated by the U.S. Court of Appeals for the District of Columbia Circuit (D.C. Circuit) in its July 11, 2008 decision in North Carolina v. Environmental Protection Agency. 531 F.3d 896 (D.C. Cir. 2008) However, on December 23, 2008, the D.C. Circuit decided to allow CAIR to remain in effect until it is replaced by a rule consistent with the court's earlier opinion. 550 F.3d 1176 (D.C. Cir. 2008) The NEMS-BT model used for the final rule incorporates the impacts of the CAIR on NO_X emissions. The reported NO_X emissions reductions refer to those States not covered by the CAIR caps.

Future emissions of Hg would have been subject to emissions caps under the Clean Air Mercury Rule (CAMR), which would have permanently capped emissions of mercury for new and existing coal-fired plants in all States by 2010 (70 FR 28606). However, the CAMR was vacated by the D.C. Circuit in its decision in New Jersey v. Environmental Protection Agency. 517 F 3d 574 (D.C. Cir. 2008) Thus, DOE was able to use the NEMS-BT model to estimate the changes in Hg emissions resulting from the proposed rule.

NEMS does not estimate emissions at homes from gas-fired appliances (*e.g.*, gas-fired water heaters, direct heating equipment and gas pool heaters). Therefore, DOE made separate estimates of the effect of amended standards on CO_2, NO_X, and SO_2 emissions from gas-fired appliances, based on emissions factors derived from the literature.

In addition to providing estimates of quantitative impacts of heating products standards on CO_2 emissions and other emissions, DOE applied monetary values to represent the potential economic value of such emissions reductions. In order to estimate the monetary value of benefits resulting from reduced emissions of CO_2 emissions, DOE used the most current Social Cost of Carbon (SCC) values developed and/or agreed to by interagency reviews. The SCC is intended to be a monetary measure of the incremental damage resulting from greenhouse gas (GHG) emissions, including, but not limited to, net agricultural productivity loss, human health effects, property damage from sea level rise, and changes in ecosystem services. At the time of this analysis, the most recent interagency estimates of the potential global benefits resulting from reduced CO_2 emissions in 2010 were $4.7, $21.4, $35.1, and $64.9 per metric ton in 2007 dollars. For emissions (or emission reductions) that occur in later years, these values grow in real terms over time. DOE also estimated the potential monetary benefit of reduced NO_X and Hg emissions resulting from the considered standard levels.

For more detail on the environmental assessment, refer to chapter 16 of the final rule TSD.

2.15 EMPLOYMENT IMPACT ANALYSIS

The imposition of standards can affect employment both directly and indirectly. Direct employment impacts are changes, produced by new standards, in the number of employees at plants that produce the covered products and at the affiliated distribution and service companies. DOE evaluated direct employment impacts in the manufacturer impact analysis. Indirect employment impacts that occur because of the imposition of standards may result from consumers shifting expenditures between goods (the substitution effect) and from changes in income and overall expenditure levels (the income effect). DOE utilized Pacific Northwest National Laboratory's impact of sector energy technologies (ImSET) model to investigate the combined direct and indirect employment impacts. The ImSET model, which was developed for DOE's Office of Planning, Budget, and Analysis, estimates the employment and income effects energy-saving technologies produce in buildings, industry, and transportation. In comparison with simple economic multiplier approaches, ImSET allows for more complete and automated analysis of the economic impacts of energy conservation investments.

2.16 REGULATORY IMPACT ANALYSIS

At the NOPR stage, DOE prepared a regulatory impact analysis (RIA) pursuant to Executive Order 12866, Regulatory Planning and Review, 58 FR 51735, October 4, 1993, which is subject to review under the Executive Order by the Office of Information and Regulatory Affairs at the Office of Management and Budget. The RIA addresses the potential for non-regulatory approaches to supplant or augment energy conservation standards in order to improve the energy efficiency or reduce the energy consumption of the products covered under this rulemaking.

DOE recognizes that voluntary or other non-regulatory efforts by manufacturers, utilities, and other interested parties can substantially affect energy efficiency or reduce energy consumption. DOE based its assessment on the actual impacts of any such initiatives to date, but also considered information presented by interested parties regarding the impacts existing initiatives might have in the future.

2.17 DEPARTMENT OF JUSTICE REVIEW

Section 325(o)(2)(B)(i)(V) of the Energy Policy and Conservation Act (EPCA) states that before the Secretary of Energy may prescribe a new or amended energy conservation standard, the Secretary shall ask the U.S. Attorney General to make a determination of "the impact of any lessening of competition…that is likely to result from the imposition of the standard." (42 U.S.C. 6295) Pursuant to this requirement, DOE solicited the views of U.S Department of Justice (DOJ) on any lessening of competition that is likely to result from the imposition of a proposed new energy conservation standard. DOE has given the views provided full consideration in assessing economic justification of the amended standard levels.