DEPARTMENT OF ENERGY

Office of Energy Efficiency and Renewable Energy

10 CFR Part 430

[Docket No. EE–RM/STD–98–440]

RIN 1904–AA77

Energy Conservation Program for Consumer Products: Energy Conservation Standards for Central Air Conditioners and Heat Pumps

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

ACTION: Supplemental Advance Notice of Proposed Rulemaking.

SUMMARY: The Department of Energy publishes this Supplemental Advance Notice of Proposed Rulemaking (ANOPR) to consider amending the energy conservation standards for central air conditioners and heat pumps.

The purpose of this Supplemental ANOPR is to provide interested persons with an opportunity to comment on:

First, the product classes that the Department is planning to analyze;

Second, the analytical framework, models (*e.g.,* the Government Regulatory Impact Model (GRIM)), and tools (e.g., a Monte Carlo sampling methodology, and life-cycle cost (LCC) and national energy savings (NES) spreadsheets) that the Department has been using in performing analyses of the impacts of energy conservation standards;

Third, the results of preliminary analyses for the engineering, LCC, payback and NES contained in the Preliminary Technical Support Document (TSD): Energy Efficiency Standards for Consumer Products: Central Air Conditioners and Heat Pumps and summarized in this Supplemental ANOPR; and

Fourth, the candidate energy conservation standard levels that the Department has developed from these analyses.

DATES: Written comments must be received by February 7, 2000. The Department requests 10 copies of the written comments and, if possible, a computer disk. The Office of Building Research and Standards is currently using WordPerfect 8.

A public hearing will be held on December 9, 1999, from 9 am-5 pm. See Section IV of the Supplementary Information for further details.

ADDRESSES: Written comments should be submitted to: U.S. Department of Energy, Attn: Brenda Edwards-Jones, Office of Energy Efficiency and Renewable Energy, ''Energy Efficiency Standards for Consumer Products,'' (Docket No. EE–RM–94–403), EE–431, Forrestal Building, 1000 Independence Avenue, SW, Room 1J–018, Washington, DC 20585, (202) 586–2945.

The public hearing will be held at the U.S. Department of Energy, Forrestal Building, 1000 Independence Avenue SW, Room 1E–245, Washington, DC 20585.

Copies of the Preliminary TSD: Energy Efficiency Standards for Consumer Products: Central Air Conditioners and Heat Pumps may also be obtained from: U.S. Department of Energy, Office of Building Research and Standards, 1000 Independence Avenue, SW, Rm 1J–018, Washington, D.C. 20585–0121, (202) 586–9127. The Preliminary TSD will also be available through DOE's web site. The Preliminary TSD provides the technical details of the analysis that was conducted in support of the Supplemental ANOPR being issued today.

Public Information: The public may visit the Freedom of Information Reading Room, located at the US Department of Energy, Forrestal Building, 1000 Independence Avenue, SW, Room 1E–190, Washington, DC 20585 between the hours of 9 am and 4 pm, Monday through Friday, (except Federal holidays). Call (202) 586–3142 for information.

For more information concerning public participation in this rulemaking proceeding, see section IV, ''Public Comment Procedures,'' of this document.

FOR FURTHER INFORMATION CONTACT: Dr. Michael E. McCabe, U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy, Forrestal Building, Mail Station EE–41, 1000 Independence Avenue, SW, Washington, DC 20585–0121, (202) 586–0854, E-mail: Michael.E.McCabe@ee.doe.gov.

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SUPPLEMENTARY INFORMATION:

I. 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. Law 95–619, the National Appliance Energy Conservation Act of 1987, 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, (EPCA or the Act), created the Energy Conservation Program for Various Consumer Products other than Automobiles. 42 U.S.C. 6291–6309.

The National Appliance Energy Conservation Act of 1987 amended EPCA to impose performance standards for central air conditioners and heat pumps as part of the energy conservation program for consumer products. EPCA, section 325(d), 42 U.S.C. 6295 (d). EPCA also requires the Department to publish final rules thereafter, to determine if these standards should be amended.

Before the Department determines whether to adopt a proposed energy conservation standard it must first solicit comments on the proposed standard. EPCA, section 325 (p), 42 U.S.C. 6295 (p). Any new or amended standard must be designed so as to achieve the maximum improvement in energy efficiency that is technologically feasible and economically justified. EPCA, section 325(o)(2)(A), 42 U.S.C. 6295 (o)(2)(A). To determine whether economic justification exists the Department must review comments on the proposal and determine that the benefits of the proposed standard exceed its burdens based to the greatest extent practicable, weighing the following seven factors:

(1) The economic impact of the standard on the manufacturers and on the consumers of the products subject to such 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, initial charges, or maintenance expenses for the covered products that are likely to result directly from the imposition of the standard;

(3) The total projected amount of energy 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 conservation; and

(7) Other factors the Secretary considers relevant.

EPCA, Section 325(2)(B), 42 U.S.C. 6295(2)(B)

B. Background

1. History

The Energy Policy and Conservation Act, as amended (EPCA or Act), requires the Department of Energy (DOE or Department) to consider amending the energy conservation standards for certain major household appliances. In 1992, the Department initiated engineering and LCC studies for central air conditioners and heat pumps based on use of computer simulation models. An ad hoc working group was formed to advise the Department and to provide engineering and test data to use with the computer models. The working group, which included representatives from central air conditioner and heat pump manufacturers, the Air Conditioning & Refrigeration Institute (ARI), Lawrence Berkeley National Laboratory (LBNL), and Oak Ridge National Laboratory (ORNL), also provided production cost data for establishing the cost-effectiveness of the various design options selected for study.

On September 8, 1993, the Department published an ANOPR (58 FR 47326) which discussed the number of product classes and design options, the computer simulation models, and the methodologies which the Department intended to use in its analysis of increased energy efficiency standards for central air conditioners and heat pumps. After the ANOPR was issued, the Department continued its analysis of LCCs, payback periods, and preliminary NES which were shared with representatives from the air-conditioning industry.

In 1995, the Department abandoned the approach of using computer simulation models as a result of concerns expressed by the industry. The concerns included: the cost/performance relations derived from the computer simulations were not consistent with the experience of the industry; the assumptions and procedures were flawed; and the industry expressed doubts over the Department's experience with selection of appropriate design options.

In October, 1995, a moratorium on proposing, issuing, or prescribing energy conservation standards took effect pertaining to standards for central air conditioners and heat pumps, and the dialogue between the air-conditioning industry and the Department, on the analysis performed, was suspended.

2. Process Improvement

During consideration of the fiscal year 1996 appropriations, there was considerable debate about the efficacy of the standards program. The Department of the Interior and Related Agencies Appropriations Act for Fiscal Year 1996 included the aforementioned moratorium on proposing or issuing energy conservation appliance standards for the remainder of Fiscal Year 1996. See Pub. L. 104–134. Congress advised DOE to correct the standards-setting process and to bring together stakeholders (such as manufacturers and environmentalists) for assistance. In September 1995, the Department announced a formal effort to consider further improvements to the process used to develop appliance efficiency standards, calling on manufacturers, energy efficiency groups, trade association, state agencies, utilities and other interested parties to provide input to guide the Department. On July 15, 1996, the Department published a Final Rule: Procedures for Consideration of New or Revised Energy Conservation Standards for Consumer Products (hereinafter referred to as the Process Rule). 61 FR 36974.

The Process Rule outlines the procedural improvements identified by the interested parties. The process improvement effort included a review of the: (1) Economic models, such as the Manufacturer Analysis Model and Residential Energy Model; (2) analytical tools, such as the use of a Monte Carlo sampling methodology; and (3) prioritization of future rules. The Process Rule requires the evaluation of uncertainty and variability by doing scenario or probability analysis (as detailed in the Process Rule, 10 CFR part 430, subpart C, appendix A sections 1(f), 4(d)(2), and 10(f)(1)). In addition, an Advisory Committee on Appliance Energy Efficiency Standards, consisting of a representative group of these interested parties, was established to make recommendations to the Secretary regarding the implementation of the Process Rule.

The Process Rule is applicable in this rulemaking to develop new central air conditioner and heat pump standards. In this Supplemental ANOPR, the Department is presenting the framework by which it will develop the standards. The framework reflects improvements and steps detailed in the Process Rule. The rulemaking process is dynamic. If timely new data, models or tools that enhance the development of standards become available, they will be incorporated into the rulemaking. For example the Advisory Committee has made several recommendations and the Department has developed new models which are discussed in this Supplemental ANOPR.

The Department held a workshop on June 30, 1998 to discuss the analytical framework that was being proposed for conducting the central air conditioner and heat pump rulemaking. The analytical framework presented at the workshop described the different analyses (e.g., the LCC, payback and national impact analyses) to be conducted (*See* Table 1), the methods proposed for conducting them, and the relationship among the various analyses.

TABLE 1.—CENTRAL AIR CONDITIONER AND HEAT PUMP ANALYSES UNDER PROCESS RULE

ANOPR	NOPR	Final Rule
Screening Analysis	Revised Pre-ANOPR Analyses (LCC and National Impacts Analyses).	Revise Analyses (LCC and National Impacts Analyses).
Engineering Analysis	Consumer Sub-group Analysis.	
LCC Analysis	Industry Cash Flow Analysis (GRIM).	
Preliminary National Impacts Analysis	Manufacturer Impact Analysis.	
	Utility Impact Analysis.	
	Environmental Analysis.	

A number of concerns were raised at the framework workshop relating to the application of the Process Rule to the central air conditioner and heat pump rulemaking, with particular emphasis on (1) the appropriate approaches for conducting the Engineering Analysis, (2) how to validate manufacturer cost figures submitted by ARI, (3) methods for developing consumer equipment price data, and (4) how non-regulatory issues, e.g., the phase-out of hydro-fluoro-chloro-carbon (HCFC) refrigerants might affect the effective date of any new standards.

In response to the concerns and comments of interested parties at the Framework Workshop, the Department decided to perform the Engineering Analysis based on the efficiency-level approach rather than the design option approach, using cost data submitted by manufacturers in aggregate via their trade association, ARI. The Department also decided to utilize a reverse engineering approach as a ''stand alone'' analysis for developing manufacturer costs and validating the ARI-provided manufacturer's cost data. Both approaches are discussed in detail in the discussion of the Engineering Analysis (II C.).

As part of the information gathering and sharing process, the Department and its contractors met several times with members of the ARI Unitary Equipment Regulatory Committee, presenting the preliminary manufacturer costs developed through the reverse engineering approach and demonstrating the LCC spreadsheet model. During this time period, ARI submitted relative production cost data for the four different product classes of central air conditioners and heat pumps (split system and single package for both air conditioners and heat pumps) for 3-ton capacity systems at various efficiency levels. Efficiency levels are defined differently for air conditioners and for heat pumps. Air conditioner efficiency is defined by the descriptor, Seasonal Energy Efficiency Rating (SEER). Heat pump efficiency is defined by the descriptor, Heating Season Performance Factor (HSPF) while operating during the heating season and by SEER while operating during the cooling season. The cooling season efficiencies provided by ARI ranged from 11 to 14 SEER. The individual manufacturers provided their costs, which were normalized to 10 SEER equipment costs, to ARI. ARI aggregated the individual manufacturers' costs and provided the Department with minimum, maximum and shipment-weighted mean values.

As will be discussed in the Engineering Analysis, the ARI-provided and reverse engineering manufacturer costs overlap considerably, especially at the lower efficiency levels in the split air conditioning class and in the middle efficiency levels of the split heat pump class. For the most part, the range between ARI's minimum and mean manufacturer costs completely encompasses the reverse engineering costs. This agreement is encouraging given the levels of uncertainty and variability involved in estimating representative manufacturer costs under different efficiency baselines across a diverse industry. These areas of convergence provide an excellent indication of the most likely costs of producing equipment utilizing today's technology under new standard levels.

Although the two sets of manufacturer costs do overlap, they disagree in some respects. In particular, there are significant differences in the breadth of the manufacturer cost distributions at each efficiency level. The Department assumes that vigorous competition in the market for minimum-efficiency equipment will compel manufacturers to meet new standards at similar incremental manufacturer costs, and that the market cannot sustain as broad a range of costs as ARI's results may imply. Furthermore, we cannot replicate ARI's maximum manufacturer costs without altering our underlying assumptions beyond what we currently consider justified.

The Department and ARI have worked diligently to identify possible sources of those discrepancies. The Department sincerely appreciates ARI's and its members' dedicated participation in the Engineering Analysis. Their relative manufacturer costs provide a solid foundation for further analysis, and their frequent review of and input to our validation effort is a valuable addition to our understanding of the production and design issues associated with meeting higher standards. The Department will work with ARI to understand the remaining differences between our two sets of manufacturer costs.

With regard to the LCC, payback, and preliminary national impact analyses, three new spreadsheet tools were developed for this rulemaking in an effort to meet the objectives of the Process Rule. The first spreadsheet calculates LCC and payback. The second one calculates impacts of standards at various levels on shipments. The third calculates the NES and national net present values (NPV) at various standard levels. These spreadsheets and the results of the preliminary analysis were posted on the Department's web site on August 24, 1999. The preliminary results posted on the web consisted of two sets of data: one set based on the manufacturer costs submitted by ARI and the other set based on manufacturer costs developed through reverse engineering. The Department suggested that any errors in the web site materials be immediately brought to our attention for correction, and that any other comments be submitted during the 75 day period following publication of this Supplemental ANOPR.

The Department has reviewed the recommendations made by the Advisory Committee on Appliance Energy Efficiency Standards on April 21, 1998. (Advisory Committee, No. 96) These recommendations relate to using the full range of consumer marginal energy rates (CMER) in the LCC Analysis (replacing the use of national average energy prices), defining a range of energy price futures for each fuel used in the economic analyses and defining a range of primary energy conversion factors and associated emission reductions, based on the generation displaced by energy efficiency standards for each rulemaking. The Department has incorporated the use of consumer marginal energy rates and a range of future energy prices for the analysis that was conducted for this Supplemental ANOPR. The Department plans to incorporate the recommendations on energy conversion factors in future analyses for the Notice of Proposed Rulemaking (NOPR).

Today's Supplemental ANOPR pertains to central air conditioners and heat pumps and utilizes the framework described in Section II. Both written and verbal comments from the June 30, 1998 Framework Workshop are being addressed in this document. The commentor's name and organization are shown in parentheses after each comment. Written comments are further identified by a number assigned to each set of written comments received during the commentary period. Verbal comments are further identified by the page number in the workshop transcript. Written comments and the Workshop transcript are viewable at the Department's Freedom of Information Reading Room described previously.

3. Test Procedure

Section 7(b) of the Process Rule states that necessary modifications to test procedures concerning efficiency standards will be identified and proposed before issuance of an ANOPR. The residential central air conditioner and heat pump test procedure is currently being revised to improve its organization and ease of use, with a proposed rule expected in November, 1999. This revision of the test procedure is not expected to alter the measured efficiencies as determined under the existing test procedure. Therefore, the revised test procedure would not affect development of revised efficiency standards. For these reasons, revisions to the test procedure are not a "necessary modification" as that term is used in the Process Rule, but rather a routine update, and hence need not be proposed before issuance of the proposed rule for these standards.

II. Central Air Conditioner and Heat Pump Analyses

This section includes a general introduction to each analysis section and provides a discussion of issues relevant to energy conservation standards for central air conditioners and heat pumps.

The Department received a number of general comments from Energy Market & Policy Analysis (EMPA) regarding the analysis conducted for the rulemaking (EMPA, # 3). Some of these concern the rulemaking procedure, while others refer to the analytic methods, and are as follows: the methodology for evaluating standards is extremely complex and increasingly unrealistic; approaches, models, assumptions, data, and data sources need to be more detailed and should to be put out for public comment before issuance of the ANOPR; and inadequate consideration is given to the impact of standards on "real consumers" as EMPA believes that groups on the DOE Advisory Committee do not represent and protect the interests of "real consumers."

The Department appreciates the concerns expressed previously. The methods and approaches used for the analyses conducted for this Supplemental ANOPR are well described and have been released on the Department's web site prior to the issuance of this notice. Any questions or comments as to how to clarify the methodologies used in this rulemaking are always welcome and appreciated.

A. Preliminary Market and Technology Assessment

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

1. Market Assessment

a. 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. For instance, historical product shipments and prices are used to help predict future prices and shipments. Market structure data are particularly useful in conducting the competitive impacts analysis.

b. Product Specific

The Department reviewed existing literature and interviewed manufacturers to get an overall picture of the residential central air-conditioning market in the United States. Industry publications and trade journals, government agencies, and trade organizations provided the bulk of the information, including: (1) Manufacturer market share; (2) shipments by capacity and efficiency level; (3) price distribution; (4) market saturation; and (5) distribution trends. The information described is discussed in the sections where it is used in the analysis.

Edison Electric Institute (EEI) commented that contractors should be interviewed when market assessments are being developed (EEI, # 2) while the

Oregon Office of Energy (OOE) requested the Department to gather information on trends in product characteristics and non-regulatory efficiency improvement initiatives, and to interview manufacturers of components (compressors, motor/fan assemblies, heat exchangers) on initiatives to improve system efficiency. (OOE, # 7) The Department relied predominantly upon literature searches and input from equipment manufacturers while developing its market assessment, but also interviewed national contracting organizations, independent contractors and component suppliers. Of course, this market assessment is preliminary, and any additional comments will be taken into consideration when the assessment is revised.

2. Technology Assessment

a. General

Information relating to existing and past technology options and prototype designs are typically used as inputs to determine what technologies manufacturers utilize to attain higher energy efficiency levels. In consultation with interested parties, the Department develops a list of technologies that can and should be considered. Initially, the technologies encompass all those considered to be technologically feasible and serve to establish the maximum technologically feasible design.

b. Product Specific

The Department based its list of technically feasible design options on design options included in a previous ANOPR (58 FR 47326, September 8, 1993). The Department then updated the list through consultation with manufacturers of components and systems, trade publications, and technical papers. Since many options for improving product efficiency are available in existing equipment, product literature and direct examination provided additional information. Further descriptions of the most current technologies are provided in the engineering section of the Preliminary TSD.

OOE asserted that all appropriate component and system technologies must be considered in the technology assessment, and that it should include microchannel heat exchangers and electrohydrodynamic enhancement technologies (OOE, # 7). Additional technologies were considered as set forth in the Technology Screening Analysis (section II.B.3) including such emerging technologies as microchannel heat exchangers, modulating compressors, and advanced variable speed motors and controls. Electrohydrodynamic enhancement technologies were not considered as they have yet to be publicly demonstrated in prototypical central air conditioner and heat pump designs.

3. Preliminary Baseline Shipments Forecast

a. General

The Department develops a preliminary baseline forecast of product shipments that assumes no new standards. This is an initial step in an iterative process. Subsequently, a more comprehensive baseline shipments forecast is prepared using a shipments model, superceding the preliminary forecast.

The baseline shipments forecast is used as an input to the National Benefits Analysis. To perform the National Benefits Analysis, a forecast of shipment-weighted product efficiencies is prepared to the year 2030. To assess the average impact on the affected consumer, a forecast of product shipments by efficiency level was prepared for the year a new standard would come into effect.

b. Product Specific

The Department prepared a baseline shipments forecast for central air conditioners and heat pumps. Data on historical product shipments guided preparation of the preliminary baseline shipments forecast.

The Oregon Office of Energy (OOE) pointed out that non-regulatory energy efficiency programs are on the wane, and that if these programs are to be considered in shipment forecasting, it must be quantifiably demonstrated how they will transform the market (OOE, #7). Information from parties involved in market-based initiatives for increasing the sales of high-efficiency models was reviewed, but provided no quantifiable measure of how these programs impact product efficiencies on a national basis. However, because the baseline forecast assumes an efficiency distribution of 10.7 SEER, based on current sales, the impact of market-based initiatives is implicit in the baseline forecast.

OOE also noted that since central air conditioning is not an essential appliance for most areas of the country, central air conditioning purchase price elasticities will likely be different than those used for forecasting shipments in other product rulemakings (OOE, #7). Since the shipments model used in this rulemaking was prepared specifically for central air conditioners and heat pumps, the Department believes this concern is addressed. The shipments model is further described in the Preliminary National Impacts Analysis discussion in section E.1.b.ii.

B. Screening Analysis

The Screening Analysis reviews various technologies with regard to whether they: (a) Are technologically feasible; (b) are impracticable to manufacture, install and service; (c) have an adverse impact on product utility or product availability; and (d) have adverse impacts on health and safety. The subsequent Engineering Analysis does not consider or incorporate technologies that do not pass these tests, regardless of whether the Engineering Analysis takes a Design Option approach or an Efficiency-level approach. Technologies that pass the Screening Analysis tests may be considered further to determine their potential cost and efficiency impacts. The Screening Analysis also identifies possible product classes and baseline equipment to serve as a basis for further analysis.

1. Product Classes

a. General

Product types are divided into classes using the following criteria: (a) The type of energy used; (b) capacity; and (c) performance-related features that affect consumer utility or efficiency. Different energy efficiency standards are applied to different product classes. In general, classes are defined using information obtained in discussions with appliance manufacturers, trade associations, and other interested parties.

b. Product Specific

As prescribed by the National Appliance Energy Conservation Act (NAECA), central air conditioners and heat pumps are each categorized into split and single package systems, giving four product classes. The analysis performed to date includes only products in these four product classes at a nominal 3 ton capacity. However, there may be justification for establishing additional classes including product types such as:

- Through-the-wall condensing units,
- Ductless split systems,
- High-velocity space-conditioning systems, and
- Vertical packaged, wall mounted.

The Department is also considering establishing new classes defined by the cooling or heating capacity of the equipment.

OOE felt that the addition of more classes may be reasonable. For example, mini-splits and combined space/water heating systems might be considered as separate classes based on their characteristics and configuration constraints (OOE, #7).

EEI commented that the product classes be expanded to include gas-fired air-conditioning equipment. Gas-fired equipment would then not be included as a design option, but as an additional product class for which baseline models must be developed. (EEI, # 2) Although the Department appreciates EEI's comments, the NAECA definition of central air conditioners subsumes only certain types of electric driven systems. This rulemaking addresses only products covered by that definition, and thus, no consideration will be given here to developing standards for fuel driven technologies.

With regard to the additional product classes listed in this section, the Department is seeking input on whether they need to be established.

2. Baseline Equipment

a. General

The Department defines baseline equipment for each product class as the starting point for analyzing energy efficiency improvements. Baseline equipment are models with the minimum allowable energy efficiency specified by the NAECA. Such baseline equipment are typically ''low-end'' units that contain no premium features, e.g., noise reduction or appearance features.

b. Product Specific

Efficiency is the most important statistic required to establish the baseline model. Current minimum efficiency standards for split and single package system central air conditioners and central air conditioning heat pumps are 10.0 and 9.7 SEER, respectively. The current minima for the heating performance of split and single package central air conditioning heat pump systems are 6.8 and 6.6 HSPF, respectively. The Department used the split system minimum efficiency standards as the baseline efficiency for each of the above classes. If additional classes are created, the Department will apply the appropriate existing standard as the baseline efficiency for that class.

OOE agreed with the Department's intent to use the efficiency of products that just meet the current minimum NAECA requirements as the baseline efficiency. (OOE, #7)

3. Technology Screening

a. General

An initial list of efficiency enhancement options is developed from the technologies identified in the technology assessment. Then the Department, in consultation with interested parties, reviews the list to determine if they are practicable to manufacture, install and service, would adversely affect product utility or product availability, or would have adverse impacts on health and safety. Efficiency enhancement options not eliminated in the screening process are considered further in the Engineering Analysis.

b. Product Specific

Compiling a list of efficiency enhancement options provided an understanding of the technologies available to manufacturers to improve equipment efficiency. This understanding also helped the Department estimate maximum technologically feasible efficiency levels. For split air conditioners, the Department believes, based on a preliminary analysis, that 20 SEER is the highest efficiency level attainable by 2006 on a commercially practicable basis using design and technology options that pass the screening criteria. These include the following: enhanced and oversized heat transfer surfaces; variable or multispeed or variable capacity compressors; high efficiency compressors; electrically-commutated, variable-speed fan or blower motors, and thermostatic or electronic expansion valves. We assumed that the efficiency of compressors, motors, and heat transfer surfaces would improve slightly prior to the effective date of any new rule. The 20 SEER level does not depend on any emerging technologies, because the Department believes that, although those technologies could reduce the cost of the equipment in the SEER 13 to SEER 17 range compared to established technologies, the emerging technologies will not advance the maximum attainable efficiency level.

The analysis of manufacturing costs and prices was based only on technologies and designs available in mass produced products as of 1998. The Department considered the potential cost impact of emerging technologies in a separate analysis described in the Preliminary TSD. The emerging technologies that pass the screening criteria include:

- Microchannel heat exchangers
- Advanced compressors
- Variable speed motor controls

The American Council for an Energy Efficient Economy (ACEEE), OOE, Modine Manufacturing (Modine), and York International (York) all provided comments pertaining to emerging technologies. Both ACEEE and OOE suggested that all advanced or emerging technologies be considered (ACEEE, #5; Steve Nadel, ACEEE, Transcript, pp 80–81; OOE, #7) . ACEEE identified improved compressors and microchannel heat exchangers. ACEEE also stated that emerging technologies could be analyzed in the context of a reverse engineering analysis. Modine stated that PF (microchannel) heat exchangers are a viable technology for improving equipment efficiency, but their acceptance should be driven by market needs rather than through a desire to push the technology into the market (Modine, #1). Bristol Compressors (Bristol) is now bringing to market the Twin-Single (TS) compressor, a reciprocating compressor that reduces system capacity by de-activating one or more pistons under part-load operating conditions. Bristol states that this technology can increase central air conditioner and heat pump efficiency from either 10 to 12 SEER or from 12 to 14 SEER. With a variable-speed indoor blower, the TS can increase system efficiency from 10 to 14 SEER (York, #4).

In contrast, an industry representative contended that emerging technologies would already be in the marketplace if they were feasible and that, in the context of conducting an Engineering Analysis based on the use of the efficiency-level approach, emerging technologies should not be considered until they are shown to radically change the shape of the industry cost curve. (Jim Crawford, The Trane Company (Trane), Transcript, pp 81,87) ARI stated that in developing an aggregate industry cost curve, emerging technologies may or may not be included depending on whether manufacturers submitting data include them in their cost estimates (Ted Leland, ARI, Transcript, pp 85).

The Department has performed a preliminary assessment of the potential impact of these technologies on the manufacturing costs of air-conditioning equipment and is seeking comment on the following: Whether these emerging technologies do in fact pass the screening criteria; the potential impact of these technologies on manufacturing cost, operating cost, and price; whether additional emerging technologies should be considered; and whether the maximum technologically feasible level is commercially practical.

The Department notes that it is not considering fuel-driven technologies, such as gas-fired engine driven heat pumps, absorption heat pumps, and Stirling refrigeration cycles, as design options for central air conditioners and heat pumps. NAECA defines a central air conditioner and heat pump, in part, as being ‘‘powered by single phase electric current.’’ This rulemaking concerns only products that meet the NAECA definition. Thus, fuel-driven technologies are precluded from consideration here.

C. Engineering Analysis

The purpose of the Engineering Analysis is to estimate the energy savings potential from increased equipment efficiency levels and the costs of achieving those levels, compared to the baseline equipment. The increased efficiency levels are associated with increased production costs. The efficiency/cost relations developed in the Engineering Analysis are combined with end-user costs in the LCC Analysis.

1. Energy Savings Potential and Production Costs

a. General

The Engineering Analysis estimates the energy savings potential of the individual or combinations of design options not eliminated in the previous Screening Analysis. The Department, in consultation with stakeholders, uses the most appropriate means available to determine energy consumption, including an overall system approach or engineering modeling. Ranges and uncertainties in performance are established.

The Engineering Analysis involves adding individual or combinations of design options to the baseline equipment. A cost-efficiency relationship is developed to show the manufacturer cost of achieving increased efficiency. The efficiency levels corresponding to various design option combinations are determined from manufacturer data submittals and from DOE engineering calculations.

EPCA requires that, any new or amended standard, ‘‘shall be designed to achieve the maximum improvement in energy efficiency that the Secretary determines is technologically feasible and economically justified.’’ EPCA, section 325(l)(2)(A), 42 U.S.C. 6295(l)(2)(A). An essential role of the Engineering Analysis consists of identifying the maximum technologically feasible level. The maximum technologically feasible level is one that can be reached by the addition of efficiency improvements and/or design options, both commercially feasible or in working prototypes, to the baseline equipment. The Department believes that the design options must have been physically demonstrated in at least a prototype form to be considered technologically feasible.

Three methodologies can be used to generate the manufacturing costs needed for the Engineering Analysis. These methods include: (1) The design-option approach, reporting the incremental costs of adding specific design options to a baseline model; (2) the efficiency-level approach, reporting relative costs of achieving energy efficiency improvements; and/or (3) the reverse engineering or cost-assessment approach which requires a ‘‘bottoms-up’’ manufacturing cost assessment based on a detailed bill of materials for models that operate at particular efficiency levels. The Department considers public comments in determining the best approach for a rulemaking.

If the efficiency-level approach is used, the Department will select appropriate efficiency levels for data collection on the basis of: (1) Energy savings potential identified from engineering models; (2) observation of existing products on the market; and/or (3) information obtained for the technology assessment. Stakeholders will be consulted on the efficiency-level selection.

The use of a design-option approach provides useful information such as the identification of potential technological paths manufacturers could use to achieve increased product 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 does not reflect the variability in design strategies and cost structures that can exist among manufacturers. Therefore, the Department may derive additional manufacturing cost estimates from other approaches developed in consultation with interested parties.

The reverse engineering or cost-assessment approach can be used to supplement the efficiency-level or design option approaches under special circumstances when data is not publically available for proprietary reasons, the product is a prototype and/or the data is not provided by the manufacturers.

b. Product Specific

The Department, in consultation with stakeholders, has used both overall efficiency level and reverse engineering approaches. The efficiency-level analysis relies upon manufacturer cost submittals from ARI while the reverse engineering analysis relies upon manufacturer costs developed by Arthur D. Little, Inc. (ADL) for the Department. The design options selected in the Screening Analysis helped to establish potential efficiency improvements.

Manufacturing cost estimates under the efficiency-level approach were submitted by individual manufacturers to ARI. For purposes of ensuring manufacturer confidentiality, ARI submitted to the Department minimum, maximum, and shipment-weighted averages of incremental manufacturer cost increases associated with various efficiency levels. In the case of the reverse engineering approach, ADL derived manufacturing cost estimates from detailed incremental cost data enabling them to establish costs for labor, purchased parts and material, shipping/packaging, and investment. Both sets of manufacturer costs were input into the Engineering Analysis and cost-efficiency relationships were developed to show the manufacturing costs of achieving various levels of increased efficiency.

As discussed earlier in the section on Process Improvement, attempts were made to reconcile differences between the ARI and the preliminary reverse engineering production cost data. Feedback from the industry resulted in revising the reverse engineering production costs of such components as outdoor cabinet (labor and materials), indoor coil (materials) and refrigerant materials. Packaging and shipping costs were also revised. The Department is continuing consultations with manufacturer representatives regarding other industry suggested issues, including manufacturing production volume, copper and aluminum raw material costs, compressor costs, indoor and outdoor coil costs, and freight costs. For more detail on how the ARI and the reverse engineering costs were developed, and our revisions to the reverse engineering costs, please refer to the Preliminary TSD. As noted earlier, these revisions helped to reconcile some of the differences between the ARI production costs and the reverse engineering production costs, but remaining differences between the two sets of manufacturer cost require further examination.

i. Efficiency-Level Approach

The efficiency-level approach establishes the relationship between manufacturer cost and increased efficiency at predetermined efficiency levels. It has the distinct advantage of being simple and straight forward. Manufacturers typically provide incremental manufacturer cost data for incremental increases in efficiency. Cost-efficiency curves can be easily constructed to clearly identify at what point manufacturers are incurring significant costs to raise efficiency. Additionally, the efficiency-level approach allows manufacturers the ability to supply detailed cost data without revealing their unique design strategies for achieving increased efficiency levels.

But the simplicity of the efficiency-level approach is also its primary drawback. Namely, since technological details are not provided, it is extremely difficult to verify whether the costs provided for each specific efficiency level are truly representative of the costs for that level. In addition, prototypical designs become difficult to evaluate and maximum technologically feasible designs are then difficult to ascertain. As a result, some other type of analysis is likely needed in order to verify the accuracy of the costs supplied through the efficiency-level approach.

In reply to the Department's request to stakeholders at the 1998 Framework Workshop regarding the most appropriate approach which should be pursued for the Engineering Analysis, some industry members stated their support for the efficiency-level approach (Ted Leland, ARI; David Lewis, Lennox International Inc (Lennox), Transcript, pp 55–56, 61, 76). More specifically, these industry members stated their intention to provide costs under the efficiency-level approach as one cost-efficiency curve that would represent an aggregate of the entire industry, i.e., a smooth curve relating the relative manufacturer cost increases associated with increased efficiency. Industry indicated that the curve would represent the 90th percentile, i.e., the cost efficiency level at which 90% of manufacturers would be able to produce product.

ACEEE and the OOE stated they would be willing to accept the efficiency-level approach only if certain conditions were met (ACEEE, #5, OOE, #7; Steven Nadel, ACEEE, Transcript, pp 65-67; Charlie Stephens, OOE, Transcript, pp 65–67). For example, in addition to providing costs at the 90th percentile, costs at multiple percentiles should be reported. Having the full distribution of costs allows for a more meaningful probability analysis to be conducted. With regard to heat pumps, costs should be collected for achieving different HSPF levels in addition to providing costs at different SEER levels. ACEEE and OOE stated that verification of the costs submitted is extremely important and they suggest that DOE staff members or consultants be permitted to inspect raw data in order to ascertain its reasonableness. OOE suggested that a reverse engineering or design option approach be used to verify the cost data, although they prefer the design option approach. ACEEE also contended that a design approach could be used to verify cost data. ACEEE stated that it is more important to verify costs submitted for high-efficiency equipment (14 to 15 SEER) as current market prices do not reflect mature market costs. Both the Consortium for Energy Efficiency and the Pacific Gas and Electric Company (PG&E) supported ACEEE's conditions for adopting the efficiency-level approach (CEE, #6; PG&E, #8). In addition, PG&E believed that the cost of efficiency upgrades for heat pumps will be similar to air conditioners since their components are nearly identical (PG&E, #8).

On the issue of cost verification, one industry representative contended that if industry provided disaggregated cost data it would allow for the determination of the sources of the data and, thus, result in violation of anti-trust laws. (Jim Crawford, Trane, Transcript, pp 70–72) In any case, he stated that if the reverse engineering approach were used and it validated the aggregated industry cost-efficiency curve the issue of cost verification would be a moot point.

The Department selected two approaches, one of which was the efficiency-level approach, for conducting the Engineering Analysis. Specific efficiency levels were selected by the Department based on consultations with stakeholders. In the case of central air conditioners, efficiency levels were based upon SEER. Efficiency levels for heat pumps were based upon both the cooling season SEER and the heating season HSPF efficiencies.

ARI collected data from individual manufacturers and, rather than providing only costs at the 90th percentile, submitted minimum, maximum, and shipment-weighted mean incremental manufacturer costs for five distinct efficiency levels (11, 12, 13, 14, and 15 SEER). ARI also provided incremental manufacturer costs for heat pumps for the same five SEER levels. Since heat pumps are also rated for their heating performance using the HSPF efficiency descriptor, the Department developed a simple relationship between the two efficiency descriptors for purposes of setting an HSPF standard in addition to an SEER standard. The Department assumed the following set of heating seasonal performance factors corresponding to the above five SEER levels: 7.1, 7.4, 7.7, 8.0, and 8.2 HSPF).

Tables 2 to 5 show the incremental manufacturer costs, also called manufacturer cost multipliers, which ARI submitted for the four primary product classes for systems with cooling capacities of approximately 3 tons (36,000 Btu/hr). The manufacturer cost multipliers are used together with the baseline manufacturer cost (which will be presented in Section II.C.2.b.) to determine the manufacturer costs for each efficiency level. For example, the mean manufacturer cost multiplier for an 11 SEER split system air conditioners from Table 2 is 1.16 and the baseline manufacturer cost for a split system air conditioner is $454. Thus, the mean manufacturer cost for an 11 SEER split system air conditioner is the product of the baseline manufacturing cost ($454) and the cost multiplier (1.16), or $527. While the manufacturer cost multipliers in Tables 2 to 5 included low and high values as well as mean values, because the probability distribution for the cost data at a given standard level are unknown, only the mean values were subsequently used in the LCC Analysis (section II.D).

TABLE 2.—SPLIT SYSTEM AIR CONDITIONERS—ARI MANUFACTURER COST MULTIPLIERS

SEER	Low	Mean	High
10	....	1.00	....
11	1.03	1.16	1.30
12	1.09	1.36	1.55
13	1.30	1.63	1.90
14	1.60	2.03	3.00
15	1.81	2.40	3.50

TABLE 3.—SPLIT SYSTEM HEAT PUMPS—ARI MANUFACTURER COST MULTIPLIERS

SEER/HSPF	Low	Mean	High
10/6.8	....	1.00	....
11/7.1	1.05	1.10	1.15
12/7.4	1.11	1.24	1.35
13/7.7	1.17	1.44	1.66
14/8.0	1.30	1.64	1.88
15/8.2	1.75	2.09	2.52

TABLE 4.—SINGLE PACKAGE AIR CONDITIONERS—ARI MANUFACTURER COST MULTIPLIERS

SEER	Low	Mean	High
10	....	1.00	....
11	1.03	1.19	1.27
12	1.15	1.30	1.40
13	1.40	1.63	1.75
14	1.59	1.87	2.00

TABLE 4.—SINGLE PACKAGE AIR CONDITIONERS—ARI MANUFACTURER COST MULTIPLIERS—Continued

SEER	Low	Mean	High
15	1.89	2.23	2.92

TABLE 5.—SINGLE PACKAGE HEAT PUMPS—ARI MANUFACTURER COST MULTIPLIERS

SEER/HSPF	Low	Mean	High
10/6.8	....	1.00	....
11/7.1	1.06	1.14	1.25
12/7.4	1.06	1.28	1.50
13/7.7	1.45	1.60	1.90
14/8.0	1.65	1.75	2.30
15/8.2	1.93	2.13	2.47

In response to EEI's comment that the Engineering Analysis should include the impact of any standard on the EER rating of the equipment (EEI, #2), the Department plans on conducting a Utility Impact Analysis for the Notice of Proposed Rulemaking (NOPR). The Utility Impact Analysis will capture the peak power impacts of an increased SEER standard, which EEI is alluding to in their comment regarding the EER.

ii. Reverse Engineering Analysis

As mentioned in the previous section, a reverse engineering approach was conducted in parallel with the efficiency-level approach to validate the ARI production cost data. The use of a component-based technology-costing (reverse engineering) approach provides useful information including the identification of potential technological paths manufacturers could use to achieve increased product energy efficiency. Under this type of analysis, actual equipment on the market is physically analyzed, *i.e.,* dismantled, component-by-component to determine what technologies and designs manufacturers employ to increase efficiency. Independent costing methods or manufacturer and component supplier data are then used to estimate the costs of the components. This approach has the distinct advantage of using ''real'' market equipment to establish the technologies which manufacturers use as the basis for estimating the cost to reach higher efficiencies.

The primary disadvantage of reverse engineering is the time and effort required to analyze ''real'' equipment. Several models from a diverse range of manufacturers may have to be assessed in order to ensure that an accurate representation of technological paths for increasing efficiency are identified. In addition, since only equipment in the market is analyzed, prototypical designs may not be captured by the analysis, thus making it difficult to establish maximum technologically feasible designs.

The industry contends that a reverse engineering approach could be used to verify the cost data submitted through the efficiency-level approach but DOE must first define the acceptable level of variability between the costs that are developed through each approach. (Jim Crawford, Trane; David Lewis, Lennox, pp 110–113) Industry also maintained that there is wide variation in production costs between manufacturers due to the levels of services that are provided with the purchase of the equipment. OOE stated that reverse engineering could be used to validate the efficiency approach (OOE, #7) while ACEEE stated that reverse engineering has the benefit of analyzing advanced technologies. (Steven Nadel, ACEEE, pp 80–81)

The Department carried out the reverse engineering approach to validate the cost estimates provided by ARI from the efficiency-level approach. The manufacturer costs of 71 equipment models at eight efficiency levels were estimated. Three 3-ton models were torn down: (1) A 10 SEER split system cooling-only condenser, (2) a 10 SEER packaged heat pump, and (3) a 12 SEER split system heat pump condenser. Manufacturer submissions, catalog data, and the ARI Product Attributes Database provided design information on the other 68 models. For split system air conditioners, cost estimates were developed for whole-number efficiency levels ranging from 10 to 17 SEER. For split system heat pumps, cost estimates were developed for whole-number efficiency levels ranging from 10 to 16 SEER. The heating efficiencies corresponding to each of the whole-number SEER levels were: 6.8 HSPF for 10 SEER, 7.1 HSPF for 11 SEER, 7.4 for 12, 7.7 for 13, 8.0 for 14, 8.2 for 15, and 8.4 for 16. A limited set of models were analyzed for single package systems. For single package air conditioners cost estimates were developed for 10, 12, and 13 SEER efficiency levels while for single package heat pumps cost estimates were developed for 10 SEER/6.8 HSPF and 12 SEER/7.4 HSPF efficiency levels.

Tables 6 to 9 show the manufacturer cost multipliers developed by reverse engineering for the four primary product classes. Probability distributions rather than single point-values were used in the LCC analysis. The low and high values shown in the following represent the 10th and 90th percentiles, respectively, of the distributions.

TABLE 6.—SPLIT SYSTEM AIR CONDITIONERS—REVERSE ENGINEERING MANUFACTURER COST MULTIPLIERS

SEER	Low	Average	High
10	0.96	1.00	1.05
11	1.08	1.13	1.18
12	1.20	1.25	1.31
13	1.35	1.42	1.48
14	1.65	1.73	1.81
15	1.87	1.95	2.04
16	1.98	2.07	2.17
17	2.13	2.23	2.33

TABLE 7.—SPLIT SYSTEM HEAT PUMPS—REVERSE ENGINEERING MANUFACTURER COST MULTIPLIERS

SEER/HSPF	Low	Average	High
10/6.8	0.96	1.00	1.05
11/7.1	0.97	1.01	1.06
12/7.4	1.05	1.10	1.15
13/7.7	1.29	1.35	1.41
14/8.0	1.57	1.65	1.72
15/8.2	1.79	1.87	1.96
16/8.4	1.92	2.01	2.10

TABLE 8.—SINGLE PACKAGE AIR CONDITIONERS—REVERSE ENGINEERING MANUFACTURER COST MULTIPLIERS

SEER	Low	Average	High
10	0.96	1.00	1.05
11	....	....	....
12	1.08	1.14	1.19
13	1.33	1.40	1.46

TABLE 9.—SINGLE PACKAGE HEAT PUMPS—REVERSE ENGINEERING MANUFACTURER COST MULTIPLIERS

SEER/HSPF	Low	Average	High
10/6.8	0.96	1.00	1.05
11/7.1	....	....	....
12/7.4	1.11	1.16	1.22

iii. Design Option Approach

Industry representatives contended that the design option approach can only be conducted by industry personnel with years of experience, but the industry is not willing to provide this expertise because of the expense involved. (Jim Crawford, Trane; David Lewis, Lennox; Ted Leland, ARI, Transcript, pp105–106) The industry also stated that DOE should not provide funds for others to carry out this approach because they lack the necessary expertise.

In contrast, ACEEE and OOE believe that the design option approach has merits (Steven Nadel, ACEEE, Transcript, p 108; OOE, #7). ACEEE stated that it can be useful for evaluating new technologies, while OOE believes it is the approach of choice for conducting the Engineering Analysis, since the impact of any single technology on cost and efficiency is explicitly stated.

The Department used only the efficiency level and reverse engineering approaches to establish the manufacturer costs of achieving increased efficiency levels for the following reasons: (1) Central air conditioners and heat pumps are complex products; (2) a wide variety of options exist to improve their efficiency; (3) these options interact in complex ways; and (4) the industry strongly opposed use of the design option approach and was willing to provide data for the efficiency-level approach.

iv. Outside Regulatory Changes Affecting the Engineering Analysis

There sometimes occur regulatory changes outside of the EPCA efficiency standards process that can affect the manufacture of a product. In some cases, such changes affect the energy efficiency of a product. The Department has attempted to identify all regulatory issues outside the efficiency standards process that would influence the Engineering Analysis.

The central air conditioning and heat pump industry faces the impending phase-out of HCFC–22, the refrigerant used in almost all the equipment currently being installed in the U.S. The phase-out of HCFC–22 begins in the year 2010, and the industry has responded by conducting in-depth analyses of various HCFC–22 alternatives. The most notable effort to date has been the ARI's Alternative Refrigeration Evaluation Program (AREP). Under AREP, several HCFC–22 alternatives were identified, and their effects on equipment capacity, efficiency, and longevity, and other variables were established.

Two primary candidates have emerged from the field of alternatives: R–410A and R–407C. Although R–410A shows promise of being able to significantly raise equipment efficiencies, its high volumetric capacity requires systems to be redesigned to handle the significantly higher discharge pressures. R–407C is a virtual drop-in replacement, but results in an efficiency degradation of 5–10% relative to HCFC–22.

In response to the issue of alternative refrigerants for HCFC–22, industry representatives stated that manufacturing costs that will be submitted will attempt to factor in the impact of switching to R–410A. (Ted Leland, ARI, Transcript, pp 287–288; Jim Crawford, Trane, p 288; David Lewis, Lennox, p 290, p 297) In response to a schedule presented at the 1998 Framework Workshop showing that a new minimum standard would become effective in the year 2005, the industry representatives stated that the effective date of any new efficiency standard should coincide with the phase-out date of HCFC–22 (the year 2010) or be in the 2006 to 2010 time frame. Additionally, they warned that efficiency gains through the use of R–410A are not as great as first believed.

In response to industry's proposal to postpone the effective date of the standard, both ACEEE and OOE stated that DOE should make new standards effective in 2005. (ACEEE, #5; OOE, #7; Steven Nadel, ACEEE, Transcript, p 298; PG&E, #8) In their view, any delay will compromise U.S. commitments to reduce global warming gases. OOE offers two approaches for completing the rulemaking on-schedule: (1) Base the rulemaking analysis on replacement refrigerants or (2) base the analysis on HCFC–22 and use a correction factor to adjust equipment performance based on the use of alternative refrigerants. PG&E adds that an effective date of 2005 will allow any new building standards proposed by the California Energy Commission (CEC) to include the beneficial impact of higher-efficiency air conditioners. PG&E states that if standards are delayed to 2010, then over 500,000 new California dwellings would be significantly less efficient.

The Department has determined that the phase-out date for HCFC–22 is far enough in the future that it will not affect a manufacturer's ability to meet any new efficiency standards, whether using HCFC–22 before the phase-out, or using alternative refrigerants before and after the phase-out. The Department does not plan to delay the effective date of any new standards to coincide with the phase-out date of HCFC–22. The Engineering Analysis has therefore been based on the assumption that equipment will use HCFC–22. However, the Department recognizes that equipment design changes to accommodate alternate refrigerants may alter the manufacturing cost-efficiency relationship developed for HCFC–22 equipment. The Department welcomes input regarding the analysis of equipment designed for alternate refrigerants.

Other non-regulatory issues of concern to the industry include the need to make systems increasingly tighter to prevent refrigerant leaks due to the use of HCFC-based refrigerants (David Lewis, Lennox, Transcript, p 298), and international standardization of test procedures. (Jim Crawford, Trane, Transcript, pp 298–299). The Department has not explicitly addressed these concerns in its current analysis but welcomes any comments as to how to address these issues in the course of the rulemaking.

2. Manufacturing Costs

a. General

In addition to being inputs to the Engineering Analysis, manufacturing costs are used as the means of determining retail prices, and are needed for the manufacturer impact analysis.

b. Product Specific

Two sets of manufacturing costs were prepared. Using an efficiency-level approach, ARI collected data from individual manufacturers and submitted incremental manufacturing cost estimates. The Department also conducted a reverse engineering analysis to determine manufacturing costs. This analysis included an assessment of uncertainty and variability among manufacturers.

Baseline manufacturer costs, *i.e.,* the costs associated with producing equipment with efficiencies of 10 SEER, were also developed through the reverse engineering analysis. Table 10 shows the baseline manufacturer costs developed for the four primary product classes for systems with cooling capacities of approximately 3 tons (36,000 Btu/hr). Note that for split system air conditioners, two costs were developed; one for systems sold without indoor blowers and the another for systems sold with indoor blowers. (A split system air conditioner is usually sold without an indoor blower when the air conditioner's indoor unit is installed in conjunction with a heating furnaces that is equipped with a blower). The uncertainty and variability of the baseline costs are noted in the manufacturer cost multipliers derived in the reverse engineering analysis (Tables 6 to 9) in the rows identified as 10 SEER/6.8 HSPF.

TABLE 10.—BASELINE MANUFACTURER COSTS

Product Class	Without blower	With blower
Split System A/C	$367	$454

TABLE 10.—BASELINE MANUFACTURER COSTS—Continued

Product Class	Without blower	With blower
Split System Heat Pump	....	615
Single Package A/C	....	534
Single Package Heat Pump	....	589

i. Characterizing Uncertainty

Consistent with the Process Rule, DOE places a range around the average manufacturing costs of achieving various efficiency levels. The OOE concurs with DOE's plan for dealing with uncertainty and variability in manufacturer cost estimates. (OOE, #7) The ranges of costs are used to generate retail prices for the consumer LCC Analysis, and are used in the Industry Cash Flow Analysis.

ARI collected data from manufacturers and developed a shipment-weighted mean, along with minimum and maximum cost multipliers for each efficiency level to account for variability and uncertainty. Since the actual distribution of manufacturer costs were not provided to the Department, only the shipment-weighted means were used in the calculation of retail prices and, in turn, the LCCs.

In conducting the reverse engineering approach, the Department developed a range of cost estimates for each efficiency level. For each efficiency level in each product class, the range of cost estimates were approximated by multiplying the mean value by a uniform distribution (from 95% of the mean to 105% of the mean) and a normal distribution (centered on the mean, with a standard deviation of 1.9%). The resulting cost distributions were then used in the calculation of retail prices and, in turn, the LCCs.

ii. Variability in Cost Among Manufacturers

The Department is committed to assessing the differential impacts of standards on different manufacturers. The results are used as inputs for the sub-group analysis of manufacturing impacts, which entails calculating cash flows separately for each class of manufacturer.

In previous analyses for other appliances, manufacturing costs submitted to DOE have demonstrated large variability. In line with the Department's preference, ARI therefore collected cost data disaggregated by manufacturer, although, as discussed earlier, ARI provided to the Department only aggregated shipment-weighted manufacturer costs. Under the efficiency-level approach, this same disaggregated company-specific cost information developed for the Engineering Analysis can be used to perform Government Regulatory Impact Analysis for each manufacturer or manufacturer subgroup. These aggregated data, however, were insufficient to generate distributions of costs by manufacturer. Therefore, only mean values were used in the subsequent LCC Analysis.

iii. Proprietary Design

The Department considers in its analysis all design options that are commercially available or present in a working prototype, including proprietary designs. OOE stated that designs meeting the stated criteria of a proprietary design should be analyzed as a design option, providing the example of the microchannel heat exchanger (OOE, #7). Proprietary designs are considered in the Department's engineering and economic analyses. The Department looked at the potential impact of proprietary heat exchanger and compressor designs plus any proprietary designs that were part of equipment which were analyzed in the course of the reverse engineering analysis.

The Department considered the potential impact of proprietary designs as part of its preliminary assessment of design options. Its initial conclusion is that the inclusion of proprietary designs will not materially affect the results of the Engineering Analysis because equipment can achieve the same efficiencies competitively using non-proprietary designs. The Department intends to continue examining this issue during the Manufacturing Impact Analysis and welcomes input on the appropriateness of considering proprietary designs.

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

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

To address these provisions the Department calculates changes in LCCs to the consumers that are likely to result from the proposed standard, as well as two different simple payback periods, i.e., distribution of payback periods, and a payback period calculated for purposes of the rebuttable presumption clause. The effects of standards on individual consumers include changes in operating expenses (usually lower) and changes in total installed cost (usually higher). The net effect is analyzed by calculating the change in LCC as compared to the base case. The base case manufacturing cost is determined in the reverse engineering analysis. The LCC calculation considers installed consumer cost (equipment purchase price plus installation cost), operating expenses (energy, repair, and maintenance costs), appliance lifetime, and discount rate. The LCC Analysis is performed from the perspective of the consumer.

At the ANOPR stage, the Department generates LCC and payback period results as probability distributions using a simulation based on Monte-Carlo methods, in which inputs to the analysis consist of probability distributions rather than single-point values. As a result, the Monte Carlo analysis produces a range of LCC and payback period results rather than single-point values. A distinct advantage of this type of approach is that the percentage of consumers achieving LCC savings or attaining certain payback values due to an increased efficiency standard can be identified in addition to the average LCC savings or average payback for that standard. Because the analysis is being conducted in this manner, the uncertainties associated with the various input variables (as described in the next paragraph) can be expressed as probability distributions. During the post-ANOPR consumer analysis, the Department will evaluate additional parameters, and prepare a comprehensive assessment of the impacts on sub-groups of consumers.

The LCC and one of the payback periods (distribution of payback periods) 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 probability distributions of input variables. The second payback, the Rebuttable payback based on DOE test procedure assumptions for estimating annual energy consumption, is not calculated using Crystal Ball and input probability distributions, but is instead based on the spreadsheet option allowing single-values for the input variables.

Based on the results of the Engineering and LCC Analyses, 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 efficiency level with the lowest LCC; and (3) an efficiency level 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.

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 purchase cost and energy use of central air conditioners and heat pumps consumers would buy in the year the standard becomes effective with what they would buy without a new efficiency standard. In some cases, this means comparing the baseline energy efficiency and cost with those associated with the standard level. In other cases, the standard level would also be compared to a higher-efficiency appliance purchased without new standards (but at a lower efficiency than the trial standard level). A weighted average of these payback periods, in the year a new standard level would take effect, is considered the payback for purposes of the rebuttable presumption clause.

In addressing the usefulness of the LCC Analysis, an industry representative asserted that LCCs have no relationship to market dynamics, have no relationship to what the customer will buy, and have no relationship to the cost effectiveness of any efficiency standard. (Jim Crawford, Trane, Transcript, pp 135) But section 325(l)(2)(B)(I)(II) of EPCA requires the Department to consider the savings and costs of standards, and virtually mandates performance of an LCC Analysis.

One commenter during the Framework Workshop stated that tax credits [incentives] for consumer purchases of high efficiency equipment should be included in the LCC Analysis. (Transcript, pp 243) The Department has not considered tax incentives in the LCC Analysis being presented here, because there are no such tax benefits available under Federal law. However, the Department seeks specific information from stakeholders regarding whether the Department should consider LCC analyses with alternative tax incentive scenarios.

1. LCC Spreadsheet Model

a. General

This section describes the LCC spreadsheet model used for analyzing the economic impacts of possible standards on individual consumers. The LCC spreadsheet model is available on the Department's web site for use by interested parties who wish to modify the assumptions in the models and view the results of those changes. The LCC Analysis is conducted using a spreadsheet model developed in Microsoft Excel for Windows 95, combined with Crystal Ball. The Model uses a Monte Carlo simulation to perform the analysis considering uncertainty and variability. The spreadsheet is organized so that ranges (distributions) can be entered for each input variable needed to perform the calculations.

The Department wishes to consider the impacts of varying regional climate, energy prices, and consumer behavior on LCCs and payback periods. Calculations were therefore based on a Monte Carlo uncertainty analysis in which variables are represented by probability distributions of values. With this approach, the Department could express LCCs and payback periods as national means, with ranges that fully account for regional variations in climate, electricity cost, and behavior. The spreadsheet has the capability to sample subsets of households for the analysis of particular sub-populations, e.g., low income households, and will be used for Consumer Sub-Group Impact Analysis prior to issuance of the NOPR.

An industry representative commented that an LCC Analysis based upon uncertain or distributional inputs is suspect and totally unverifiable if the uncertainty of the inputs cannot be clearly defined. (Jim Crawford, Trane, Transcript, pp 252–254) He suggested that a simpler approach be used. Others supported the use of a distributional LCC Analysis, commenting that this approach is better than what has been used in prior rulemakings. (Charles Stephens, OOE; Michael Martin, CEC, Transcript, pp 256) EEI stated that the use of ranges of values for appliance price and life, fuel costs, energy usage, and discount rates follows recommendations provided by the Appliance Standards Advisory Committee. (EEI, #2) OOE asserts that use of a distributional analysis creates potential pitfalls in accounting for regional climatic and energy price variations. Use of traditional methods for screening out design options based upon increased LCC or excessively long payback periods will be more difficult as results for one region may demonstrate that a design option is economically attractive while another region does not. DOE must establish some basis for rejecting or retaining design improvements. (OOE, #7) Although the use of distributional LCC Analysis may be more complex, the Department has decided it is the best approach to use to capture the uncertainty and variability inherent in input variables. In response to OOE's concerns for selecting appropriate standard levels, the Department will keep in mind their concerns when selecting appropriate standard levels for the NOPR.

In order to generate the distributions required for the analysis, the Department used the Energy Information Administration's (EIA's) *Residential Energy Consumption Survey* (RECS). The 1993 RECS is based on a representative sample of 7,111 households from the population of all primary, occupied residential housing units in the United States. Each household is weighted so that the data properly represent the 96.6 million households in the 50 states and the District of Columbia reported in the 1993 RECS.

RECS estimates end-use energy consumption and reports the age of equipment as well as household energy prices. Of the over 7,000 households surveyed in RECS, 2550 households representing 35.6% of the housing population have a central air conditioner while 651 households representing 8.3% of housing population have an electric heat pump. The distribution of LCC and payback results are generated by performing an LCC and payback calculation for each RECS household with a central air conditioner or heat pump. For example, in conducting the LCC Analysis for a 12 SEER standard level for central air conditioners, all RECS households with a central air conditioner have their existing equipment ''replaced'' first with a baseline (i.e.,10 SEER) system. The corresponding LCCs of the baseline systems are then calculated. Then all RECS households with a central air conditioner have their existing equipment ''replaced'' with a 12 SEER system and the LCC of these systems are established. On a household-by-household basis, the payback periods and the LCC differences of the 12 SEER system are determined relative to the economics of the baseline system. The result is a distribution of LCCs and payback periods. Since climatic conditions and consumer behavior affect the energy consumption of a given piece of equipment, these data implicitly account for regional variations. Similarly, variations in the RECS energy price data represent the range faced by consumers in the U.S.

Both EEI and EMPA warned of problems using the RECS data in a LCC and Payback Analysis. (EEI, #2; EMPA, #3) EEI asserts the following: (1) The age of the RECS data (1993) is too old to be used with efficiency and price data from 1998, (2) only total annualized average electricity and fuel rates rather than summer marginal rates are provided, (3) the stated age of the equipment may be inaccurate if the households surveyed are not original homeowners, and (4) there is no accounting of equipment used in small commercial facilities. EEI also claims that RECS may not reflect regional or national equipment saturations as the 1993 RECS shows that 42% of survey homes have a central air conditioner while an industry publication (ACHR News, June 22, 1998) shows saturations ranging from 55% in the western U.S. to 99% in the southern U.S. EMPA questioned whether the 7,000 to 8,000 households surveyed households in RECS can be representative of the 90 million households in the U.S. They also commented that RECS experts from EIA needed to provide a written statement in support of the way in which DOE plans to use the RECS data in its LCC analyses. In contrast to these comments, OOE states that they are very comfortable with the analysis methodology as it was applied to other products (clothes washers) where RECS data was used to determine annual energy use and equipment age. (OOE, #7)

Although the Department understands the concerns of the EEI and EMPA, the 1993 RECS data is the most recent and appropriate database available for conducting the desired distributional LCC Analysis. DOE plans to conduct updates to the LCC and Payback Period Analysis with the 1997 RECS. Use of this data will address most of the concerns brought up by both EEI and EMPA.

Estimates of the efficiency of equipment currently in use are based upon the age of the equipment as established by RECS and historical shipment-weighted efficiency values. The age of the equipment establishes the year of manufacture which in turn, using the shipment-weighted efficiency data, allows for the determination of the equipment's most probable efficiency. Replacing existing equipment with new equipment results in reductions in energy consumption. These reductions were approximated by multiplying current energy use by the ratio of the efficiencies of existing and new equipment. Using an energy price allowed for the calculation of the operating costs of existing and new replacement equipment, and, in turn, the LCCs and payback periods associated with different efficiency levels of new equipment.

The Department developed LCCs and payback periods based on both sets of manufacturer cost estimates developed in the Engineering Analysis: (1) The ARI cost data developed through the efficiency-level approach, and (2) the cost data developed through the reverse engineering analysis.

A more detailed description of the methodology and contents of the RECS database is contained in the Preliminary TSD.

b. Product Specific

This section discusses the approaches for analyzing the economic impacts on individual consumers from potential new central air conditioner and heat pump standards. An LCC spreadsheet model, described previously in Section II.D.1.a, is used to calculate two of the economic impacts, LCC and payback period, based on input variables that have uncertainty and variability expressed with probability distributions. A third economic impact, Rebuttable Payback Period, is determined without the use of the spreadsheet model. In future analyses, all three of these economic metrics will be compared to baseline efficiencies of appliances sold in the year the new standard would take effect. In this preliminary analysis, only the Rebuttable Payback Period is compared to a distribution of efficiencies forecasted to the year 2006.

i. LCC Analysis

The Department determined values of input variables for central air conditioners and heat pumps, including total installed cost (consisting of both the equipment purchase price and installation price), annual energy use, lifetime, repair costs, and maintenance costs of equipment, as well as average energy prices, marginal energy prices, and discount rate. Table 11 summarizes some of the major assumptions used to calculate the consumer economic impacts of various energy-efficiency levels.

TABLE 11.—ASSUMPTIONS USED IN THE LCC ANALYSIS

Total Installed Cost: Equipment Purchase Price.	Manufacturer cost multiplied by manufacturer markup, distributor markup, dealer markup, and sales tax.
Installation Price	Central air conditioners—$1190; heat pumps—$2035.
Existing Equipment Efficiency	Distribution imputed from RECS database based on equipment age and historical shipment-weighted efficiencies (central air conditioners—5.3 to 15.2 SEER, weighted average of 8.58 SEER; heat pumps—5.3 to 15.2 SEER, weighted average of 8.72 SEER; 4.88 to 9.67 HSPF, weighted average of 6.52 HSPF).
Existing Annual Energy Use	Distribution from RECS database (central air conditioners—174 to 12,929 kWh/yr, weighted average of 2629 kWh/yr; heat pumps—space-cooling equals 0 to 14,771 kWh/yr, weighted average of 2987 kWh/yr; space-heating equals 162 to 29,839 kWh/yr, weighted average of 4658 kWh/yr).
Average Energy Prices	Historical—distribution from RECS database (central air conditioners—2.70 to 16.50 ¢/kWh, weighted average 8.49 ¢/kWh; heat pumps—2.60 to 13.00 ¢/kWh, weighted average 7.86 ¢/kWh); projections—*AEO*—1999.
Marginal Energy Prices	Historical—estimated from RECS database (central air conditioners—0.58 to 19.42 ¢/kWh, weighted average 8.74 ¢/kWh; heat pumps—0.82 to 18.62 ¢/kWh, weighted average 7.99 ¢/kWh); projections—scaled to trends in average energy prices.
Lifetime	Distribution based on empirical data (mean life is 18.4 years).
Discount Rate	Distribution (0% to 19%, weighted average 6.51%)
Repair Costs	For systems with efficiencies of 10 SEER or greater than 12 SEER, one-half equipment price divided by mean lifetime. For systems with efficiencies of 11 or 12 SEER, 1% greater than the 10 SEER repair cost.
Maintenance Costs	Distribution ($0 to $135/year, weighted average $36/year).

Total Installed Cost: The total installed cost consists of the equipment purchase price and the installation price. Markups are used to convert the manufacturer cost to the equipment purchase price. The determination of equipment purchase prices is described in the next section.

Installation Price: The installation price represents all costs required to install the equipment other than the marked-up equipment cost. The installation price includes labor, overhead, and any miscellaneous materials and parts such as linesets. For central air conditioners the installation price used in the analysis used is $1190, and for heat pumps it is $2035. The installation price was determined by subtracting the derived equipment purchase price from the typical total installed cost. The typical total installed cost values were collected from public sources and phone calls to heating ventilating and air conditioning (HVAC) contractors. While the data collected were for split systems, the Department has assumed the installation prices apply to single package systems, although installation price for these systems might be somewhat lower than for the split systems, since only single packages are involved and no line sets are required. The Department is interested in obtaining information on the installation prices for all classes of products.

Annual Energy Use: Currently, the DOE test procedure calculates annual cooling and heating energy consumption based on 1,000 and 2,080 hours of operation, respectively. Although this procedure seems to be widely accepted for comparing the seasonal performance of different units, the procedure overstates equipment energy use compared to RECS estimates. As described above, basing operating and LCC on RECS household data provides a more accurate measure of the savings possible from more-efficient equipment, and accounts for variability in LCCs due to climatic conditions and energy prices.

Variations in energy use for a particular appliance can depend on factors such as climate, type of household, people in household, etc. For purposes of this analysis, annual energy use was based on the annual end-use energy consumption values in RECS. Climatic and consumer behavior are inherent to the RECS energy use data. The Department will perform sensitivity analyses prior to issuance of the NOPR to consider how differences in energy use will affect sub-groups of consumers.

For the RECS households with central air conditioners, the range of annual space-cooling energy consumption is 174 to 12,929 kWh/year with a weighted-average value of 2629 kWh/year. For the RECS households with heat pumps, the range of annual space-cooling energy consumption is 0 to 14,771 kWh/year with a weighted-average value of 2987 kWh/year. The annual space-heating energy consumption for households with heat pumps ranges from 162 to 29,839 kWh/year with a weighted-average value of 4658 kWh/year.

For each RECS household equipped with either a central air conditioner or heat pump, the annual energy use associated with a particular standard level is calculated by taking the annual energy use associated with the existing system and multiplying it by the ratio of the existing system's efficiency to the efficiency of the standard level of interest. To illustrate this approach, this calculation procedure is carried out here based on the weighted-average annual energy use and the weighted-average efficiency from all RECS households equipped with central air conditioners. As presented earlier, for all RECS households with a central air conditioner, the weighted-average annual energy use and the weighted-average efficiency are 2629 kWh/year and 8.58 SEER, respectively. Thus, for the case of a 12 SEER air conditioner, the weighted-average annual energy use is determined according to the following expression:

Weighted-average annual energy use of 12 SEER A/C = 2629 kWh/yr 4 × (8.58 SEER ÷ 12 SEER) = 1880 kWh/yr

Of course, as the efficiency of the standard level being analyzed increases, its corresponding annual energy use decreases proportionally. It should be noted that in the case of establishing the annual space-heating energy use of heat pumps, the ratio of HSPF values are used rather than the SEER values. It must also be emphasized that the above calculation is illustrative only. In order to generate the distribution of LCC and payback results for a particular standard level, each RECS household that is equipped with a central air conditioner or heat pump is analyzed.

Concerning use of RECS data in the economic analysis, EEI stated that, although energy use is dependent on equipment design, weather, and consumer operation, it is also a strong function of house design, landscape, and thermostatic controls, and their impacts should be taken into consideration. (EEI, #2) They also stated that EER ratings, in addition to SEER ratings, ranges of cooling capacity, and the climatic impact on hours of operation, should also have an impact on energy use and should also be considered. With regard to the annual operating hours, EEI stated that a range of values based upon end-use metering studies, load management programs, and other utility or research organization studies should be used. They cited state utility commissions, Internet web sites, and software providers as possible sources for determining variations on energy use.

As stated earlier, the Department believes that the 1993 RECS is the most recent and appropriate data available. In addition to the equipment design, weather, and consumer operation, the RECS annual end-use estimates also consider the household's shell characteristics including any prominent shading. Past RECS data sets have been validated against end-use metering studies in an attempt to better its procedures for estimating end-use energy consumption. Although the Department is comfortable with the use of RECS as its source for establishing annual energy consumption, interested parties are welcome to present any metered end-use data that could verify or substitute for the RECS estimates.

Average Energy Prices: As discussed above, the Department is using RECS household data to establish energy prices. Projections of future energy prices for the LCC Analysis use high, low, and reference case projections of national average electricity prices to residential customers. The current edition of EIA's *Annual Energy Outlook (AEO)* is used as the source of projections for uncertainty in the LCC analysis.

For the RECS households with central air conditioners, the range of average electricity prices in 1993$ is 2.70 to 16.50 ¢/kWh with a weighted-average value of 8.49 ¢/kWh. For the RECS households with heat pumps, the range of average electricity prices is 2.60 to 13.00 ¢/kWh with a weighted-average value of 7.86 ¢/kWh. While average energy prices establish the annual electricity cost of baseline equipment (*i.e.,* split-system air conditioners with efficiencies of 10 SEER and heat pumps with efficiencies of 10 SEER and 6.8 HSPF), marginal energy prices establish savings in electricity costs associated with increased efficiency standards.

Both EEI and EMPA stated that the average energy prices in RECS are outdated and that marginal energy prices should be used in their place in conducting the LCC and Payback Analysis. (EEE, #2; EMPA, #3) Both pointed to subtracting out the fixed cost portion of the price as an interim step in developing marginal prices. EEI suggested several data sources for developing marginal prices including state utility commissions, Internet web sites such as the PowerRates site, and software providers such as such as EPS solutions and Energy Interactive. EMPA stated that any work to identify marginal energy costs should include a detailed description of the methodology and that any data collection efforts must comply with Paperwork Reduction Act. ACEEE noted how air conditioners are used during peak periods when the cost of supplying electricity is high and that price data should be collected during these periods for use in the economic analyses. (ACEEE, #5)

Regarding future energy prices, several participants at the 1998 Framework Workshop stated that future residential electricity prices will be dependent on the how the electric utility industry is restructured. (Transcript, pp 220–230) EMPA was critical of EIA's forecasts of future energy prices, stating that the forecasts have consistently underestimated rates, and that EIA's forecasting models do not reflect the factors resulting from the deregulation of the electric utility industry. (EMPA, #3)

The Department used the most recent forecasts from the *1999 AEO* to predict the trend in both average and marginal electricity prices by multiplying the average and marginal price for the base year (1998) by the *AEO's* forecasted relative electricity price increases and/ or decreases. In addition, LCC and payback spreadsheets can be run with price forecasts from the Gas Research Institute (GRI). The Department believes these forecasts are the most reliable available to predict future energy trends.

Marginal Energy Prices: Marginal energy prices are those prices consumers pay for the last units of energy used. Marginal prices reflect a change in a consumer's bill associated with a change in energy consumed, consequently, marginal energy prices, rather than average energy prices, are appropriate for determining energy cost savings associated with increased efficiency standards. For LCC analyses, the Advisory Committee recommended that DOE use the full range of consumer marginal energy prices instead of national average energy prices. Absent consumer marginal energy price information, the Committee recommended DOE use a range of net energy prices, calculated by removing all fixed charges. The Department agrees the use of marginal energy prices improves the accuracy of the LCC Analysis and has estimated marginal prices for electricity and natural gas.

The Department estimated consumer marginal electricity and natural gas prices directly from household data in the 1993 RECS survey by calculating the slopes of the regression lines of customers' bills vs. energy consumption for these two fuels. Those slopes are equal to the change in bill divided by the change in energy consumption, that is, the marginal prices paid by each household. Since this rulemaking concerns only energy efficiency standards that apply to electrically-driven central air conditioners and heat pumps, only marginal electricity prices are of concern here.

For electricity, the Department calculated separately the slopes of the regression lines for four summer months (June–September) and for the remaining (''winter'') months. The annual marginal price was derived by taking the weighted average of the two seasonal prices, where the weighting was the relative energy consumption of the appliance in each season. For air conditioners/heat pumps, the weighting was based on the regional location and age of each of the households in the RECS sample.

Given restructuring of parts of the energy supply sector, customers may have more than one bill (e.g., one from the distribution company, and one or more from generators or suppliers). To capture complete information, future surveys would best gather energy pricing information directly from customers, rather than from utilities or local distribution companies. Efficient collection of energy pricing information in the future will require changing the current processing of the billing information so as to gather consumption by month and pricing information for each customer from the bills. The pricing information would comprise the applicable rate schedule, including marginal prices, fixed charges, and demand charges for commercial and industrial customers, or time-of-use rates where applicable. The Office of Energy Efficiency and Renewable Energy has expressed the need for these data in discussions with EIA concerning the design of future surveys.

Until a time series of marginal prices is available, the Department will use projected trends in energy prices to derive estimates of consumer marginal energy prices for the economic analysis of proposed standards. An index (scaling factor) was created relative to current prices from the trend in average prices (by fuel and sector) and was applied to the current range of marginal prices. For example, if the trend in average residential electricity prices was a decline by 20 percent over a given period of time, then we assume the marginal price for each household would decline from its initial observed value by 20 percent over that same period.

The Department recognizes that a simple scaling of marginal energy prices may be incorrect in a restructured electric power market. Therefore, the Department may develop a different approach to forecast future marginal energy prices when restructuring becomes more widely implemented.

Given the uncertainty of projections, the Department has made available to stakeholders the ability to conduct a scenario analysis to examine the robustness of different efficiency levels under different energy-price conditions. Each scenario provides a self-consistent projection, integrating energy supply and demand. The scenarios differ from each other in the energy prices that result. The Advisory Committee suggested the use of three scenarios. While many scenarios can be envisioned, the three scenarios specified are sufficient to bound the range of energy prices.

The three scenarios suggested by the Advisory Committee are based on projections in the *1999 AEO.* The Department's most recent reference case, published in the *1999 AEO,* provides a well-defined middle scenario. In addition, DOE can use the scenarios with the highest and lowest energy prices in the sector from the range of scenarios in the *1999 AEO.* The future trend in energy prices assumed in each of the three scenarios is clearly labeled and accessible in each spreadsheet. Also included as a scenario is the GRI energy price forecast for 1998. Stakeholders can easily substitute alternative assumptions in the Department's web site LCC spreadsheets to examine additional scenarios.

For the RECS households with central air conditioners, the range of marginal electricity prices in 1993 dollars is 0.58 to 19.42 ¢/kWh with a weighted-average value of 8.74 ¢/kWh. For the RECS households with heat pumps, the range of marginal electricity prices is 0.82 to 18.62 ¢/kWh with a weighted-average value of 7.99 ¢/kWh.

As discussed previously under the section describing average energy prices, marginal energy prices are used to determine the annual electricity costs associated with energy savings resulting from an increased efficiency standard (i.e., any efficiency above baseline efficiencies).

Lifetime: In choosing a value for lifetimes of central air conditioners and heat pumps, a variety of sources were reviewed. These studies on lifetimes of central air conditioners and heat pumps indicates that there is a wide range of values for lifetimes. The references are provided in Table 12, with the mean lifetimes given in years.

TABLE 12.—CENTRAL AIR CONDITIONER AND HEAT PUMP MEAN LIFETIMES

Source	In years—	
	Central AC	Heat pump
Appliance Magazine. The Life Expectancy/Replacement Picture, Sept. 1998 [a]	13.0	14
National Association of Home Builders. Housing Facts, Figures, and Trends, 1998 [b]	15.0	15
1995 ASHRAE Applications Handbook [c]	15.0	15
M.E. Bucher et al, American Electric Power Service Corp. 1990. "Heat Pump Life and Compressor Longevity in Diverse Climates", ASHRAE Transactions 96(1):1567–1571		[d] 19
K.A. Pientka, Commonwealth Edison Co. 1987. "Heat Pump Service Life and Compressor Longevity in a Northern Climate", ASHRAE Transactions 93(1):1087–1101		[d] 15–16
C.C. Hiller, EPRI and N.C. Lovvorn, Alabama Power Co. 1987. "Heat Pump Compressor Life in Alabama", ASHRAE Transactions 93(1):1102–1110		[d] 20
J.E. Lewis, Easton Consultants. 1987. "Survey of Residential Air-to-Air Heat Pump Service Life and Maintenance Issues", ASHRAE Transactions 93(1):1111–1127	12.1	10.9
MTSC, Inc. Energy Capital in the U.S. Economy, prepared for the Office of Policy, Planning, and Evaluation, U.S. Department of Energy, Nov. 1980 [e]	12.0	12

[a] Based on first-owner use. Central AC min life = 8, max life = 18. Heat Pump min life = 10, max life = 17.
[b] Sources: Air Conditioning and Refrigeration Institute; Air Conditioning, Heating, and Refrigeration News; Air Movement and Control Association; American Gas Association; American Society of Gas Engineers; ASHRAE.
[c] Source for Central A/C: Akalin, M.T. 1978. "Equipment life and maintenance cost survey", ASHRAE Transactions 84(2):94–106. Source for Heat Pump: ASHRAE Technical Committee 1.8, 1986.
[d] Median lifetime.
[e] Based on retirement function.

The available sources report mean and median lifetimes ranging from 10.9 to 20 years. The Department's analysis assumed a mean lifetime of 18.4 years, based on a 1990 ASHRAE technical paper that has the most recent and most detailed information on heat pump life available, based on a survey of 2,184 heat pump installations in a seven-state region of the United States. The sources that report shorter average lifetimes are based on data of a lesser quality, and the Department considers those figures are less reliable. For example, in the case of *Appliance Magazine,* the reported lifetime values are based on expert opinion rather than empirical data.

Appliances produced at some future date may have different lifetimes than those in the same class produced in the past. The projections of lifetimes and other parameters used in the analysis should be based on observed empirical trends, as well as expert knowledge of likely changes in the industry, since future changes are not always straight-line projections of past trends. While expert judgement is crucial, however, it must have a strong empirical basis. With this in mind, the Department believes that the probability distribution of equipment lifetime used in the analysis is the most sound, given available evidence of past performance and recent trends. Because none of the data on equipment lifetime indicates a relationship between efficiency and lifetime, the Department assumes that equipment lifetime is independent of efficiency.

EMPA claimed that lifetime should be based on first ownership rather than actual equipment life. (Glenn Schleede, EMPA, Transcript, pp 232; EMPA, #3) They stated that homeowners usually change residences every 7 years. In response to this assertion, it was stated that although the statute requires that LCC be determined it does not specify the exact meaning of lifetime. (Mike Rivest, ADL, Transcript, p 236) Counter to EMPA's claims, OOE stated that energy efficiency benefits are essentially swapped when a homeowner changes residence. (Charlie Stephens, OOE, Transcript, pp 233; OOE, #7) That is, the new homeowner will realize the benefits of the first owner's more efficient equipment. They also add that an equipment lifetime of 15 years seems reasonable for split system air conditioners, but that field data indicates that heat pumps have a shorter life.

The Department believes that equipment life rather than first ownership is the correct measure of lifetime. The Department continues to seek any additional information that may provide better data on actual air conditioner and heat pump life.

Discount Rate: Interested parties submitted several comments recommending values or procedures for determining discount rates. An industry representative suggested that rates of 18 to 20% may be appropriate as consumers are paying off credit card debt at these rates. (Jim Crawford, Trane, Transcript, p 237) He also asserted that practical (i.e., implicit) discount rates (which are derived from analyzing actual consumer behavior) may be on the order of 30%. EEI also believes that credit card interest rates should be used as a basis for establishing discount rates. (EEI, #2) EMPA believes DOE's discount rates (as presented at the 1998 Framework Workshop) are too high and based on faulty assumptions. They stated that discount rates should reflect the true cost of money that consumers would have to spend to purchase more efficient appliances. (EMPA, #3) Industry representatives also stated that questions concerning consumer discount rates should be included on any market surveys for determining retail prices and that DOE needs to take into account any information supplied by the industry's trade association, ARI. (Jim Crawford, Trane, Transcript, p 243; David Lewis, Lennox, Transcript, pp 243–244)

In contrast to these comments, OOE believes that prior discount rates developed by DOE seem reasonable, although there are differences in how consumers purchase air conditioner and heat pump equipment compared to how they purchase other appliances. (OOE, #7) They strongly disagreed that discount rates in excess of 15% might be appropriate. They claim such high rates are based on calculating an implicit discount rate or market failure factor based on past shipments.

The Department's Process Rule for establishing new or revised energy efficiency standards for consumer products describes how real discount rates are to be established for residential consumers, as follows:

For residential and commercial consumers, ranges of three different real discount rates will be used. For residential consumers, the mid-range discount rate will represent DOE's approximation of the average financing cost (or opportunity costs of reduced savings) experienced by typical consumers. Sensitivity analyses will be performed using discount rates reflecting the costs more likely to be experienced by residential consumers with little or no savings and credit card financing and consumers with substantial savings.

Based on the Department's guidelines provided in the Process Rule, a distribution of discount rates was derived to reflect the variability in financing methods consumers use in purchasing central air conditioners and heat pumps. 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 that the resulting distribution of discount rates encompasses the full range of discount rates that are appropriate to consider in evaluating the impacts of DOE 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 which fall between the high and low extreme values.

The method of purchase used by consumers is assumed to be indicative of the source of the funds and the type of financing used, although DOE is not aware of detailed research into this relationship. Consumers purchase appliances as parts of new homes (mortgages) and as separate retail purchases. Retail purchases are paid by cash, credit cards, or loans. In the case of space-conditioning equipment, the loans are assumed to take the form of second mortgages, as central air conditioner and heat pump purchases often occur when home upgrades are made. Based upon recommendations provided by the ARI, the shares of the different financing mechanisms used for purchasing central air conditioners and heat pumps were assumed to be 30% with a new home (first mortgages), 25% through loans (second mortgages), 10% paid by cash, and 35% by use of credit cards.

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 Department based its real mortgage rates on ARI's suggested mean value of 3.0% and assumed a range of 1.6 to 4.4%. Applying an assumed marginal tax rate of 28% (i.e., the maximum marginal rate paid by most U.S. taxpayers) and an assumed inflation rate of 2% results in a mean nominal mortgage rate of 6.94% with a range of 5.0 to 8.89%.

For second mortgages or loans, ARI suggested a mean real interest rate of 8.0%. This rate is more representative of a nominal rate for second mortgages and was used as such. Assuming a tax rate of 28%, then subtracting an assumed inflation rate of 2% (the same rates used to derive the new home real interest rates) we arrive at a mean real interest rate of 3.76%. Nominal minimum and maximum interest rates of 6% and 10% were assumed to arrive at the real interest rate range of 2.32% to 5.20%.

For cash, the minimum rate was assumed to equal 0%. This rate applies to purchasers making cash purchases without withdrawing from savings accounts. Based upon ARI's recommendation, the maximum is taken to be the opportunity cost represented by the interest that could have been earned in a typical mutual fund (assumed to be 6% real). A real mean rate of 3% results.

For credit cards, the Department based its real interest rate on ARI's suggested mean value of 12.5%. Minimum and maximum real rates of 6% and 19% were assumed. It should be noted that the use of these credit card rates reflects an assumption that all consumers who use credit cards do so as a means of long term financing for product purchases, rather than as simply a convenient method of purchase or as a means of short term financing.

Combining the assumed shares of each financing method, the above real interest rates result in a weighted-average (mean) value of 6.51% and a distribution that varies from 0 to 19%. Sensitivity studies show that while the LCC results are sensitive to the value chosen for mean discount rate, the LCC results are not sensitive to the distribution of discount rates.

The Department believes that the above method is a valid basis for establishing a distribution of discount rates over the full range of discount rates relevant to most purchasers of the products covered by this rulemaking, but acknowledges that different assumptions might be made about likely interest, inflation and marginal tax rates, or about consumer financing methods, and that different approaches to identifying valid consumer discount rates might also be valid. For example, it is also 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 that purchase the covered products. DOE does not believe, however, that such alternative assumptions or alternative approaches would significantly alter the range of discount rates used by the Department or the conclusions drawn from the life cycle cost 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 DOE's analysis. Alternatively, DOE is soliciting comment on the possible use of a standardized distribution of discount rates ranging from approximately 4% to 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.

Repair Costs: The annual repair cost covers the replacement or repair of components which have failed. The Department assumed repair costs for minimum efficiency equipment (10 SEER) and equipment with efficiencies greater than 12 SEER were equal one-half the equipment price divided by the mean equipment lifetime. The Department assumed equipment with efficiencies of 11 and 12 SEER incur a 1% increase in repair cost over the minimum efficiency (10 SEER) level. The rationale for assuming essentially flat repair costs through efficiencies up to and including 12 SEER pertains to the level of technology being used at these system efficiency levels. Through 12 SEER, system technology generally does not incorporate sophisticated electronic components which are believed to incur higher repair costs. Increases in SEER are generally achieved through more efficient single-speed compressors or more efficient and/or larger heat exchanger coils. Systems with efficiencies beyond 12 SEER start to incorporate modulating blowers or compressors which are generally believed to be more susceptible to failure.

Maintenance Costs: The annual maintenance cost covers such items as checking and maintaining refrigerant charge levels and cleaning heat exchanger coils. Data from Service Experts, an HVAC service company, were used to establish maintenance costs. The maintenance cost ranges from $0 to $135 with a weighted-average value of $36.

EMPA stated that DOE needs to collect and include extended warranty and service costs in LCC calculations. (Glenn Schleede, EMPA, Transcript, p 231; EMPA, #3) EMPA also requested that the assumptions regarding maintenance and repair costs be reevaluated and described in greater detail. An industry representative supported including these costs, and also stated that they will be a function of equipment efficiency. (David Lewis, Lennox, Transcript, p 231) A suggestion was made to include questions on warranty and service costs on any market survey for determining retail prices (Steven Nadel, ACEEE, Transcript, p 232). OOE endorsed the concept of accounting for differences in maintenance, service, and installation costs, provided these incremental costs are attributable only to equipment at different efficiency levels (OOE, #7).

Although the Department included maintenance costs in its LCC calculations, no attempt was made to account for warranty costs. The Department assumed that warranty costs are constant with increased efficiency and, thus, there was no need to explicitly account for warranty costs. The Department welcomes any comments that can provide insight as to how warranty costs should be accounted for in the LCC Analysis.

ii. Equipment Prices

How manufacturing costs and profit margins associated with standards are passed through from manufacturers to consumers has an impact on both consumers and manufacturers. Consumer and manufacturer economics are linked and inversely related. For this reason, equipment purchase prices used for the LCC Analysis need to be reconciled with manufacturer costs.

At the pre-ANOPR stage, a consumer LCC curve, based in part on mean installed consumer costs, is a significant factor in the initial selection of potential standards levels. Total installed costs are needed for a base case, absent new standards, and for all efficiency levels to be considered. As noted earlier, equipment purchase price coupled with the installation price equals the total installed consumer cost.

There was a great deal of discussion at the 1998 Framework Workshop concerning equipment or retail prices, because equipment prices were being viewed as a means to verify industry-supplied manufacturer cost data. Much of the discussion focused on the correlation between manufacturer costs and prices. Some claimed that there is practically a random relationship between manufacturer costs and prices and that prices are based more upon market dynamics rather than improvements in equipment efficiency. (Jim Crawford, Trane, Transcript, pp 90, 139–140) It was also stated that, due to the tremendous variability in city size, dealer groups, dealer size, dealer proximity to warehouses, bulk purchasing, and national account purchasing, the markups involved in converting manufacturer costs to retail prices are highly variable. Also, because some manufacturers use distributors while others do not, markups can vary significantly from manufacturer-to-manufacturer. (David Lewis, Lennox, Transcript, pp 168–170) It was also noted that markups are unlikely to be constant across all efficiencies. (Jim Crawford, Trane, Transcript, pp 154)

In order better to determine equipment prices, participants at the Workshop agreed that it would be appropriate to conduct a market survey. There was discussion as to whether the survey should be administered to contractors or consumers. It was pointed out that contractors may not provide true prices as they may not want to reveal their profit margins while consumers may simply not know the price of only the equipment (i.e., the price exclusive of the labor, materials and profit for installation). (Transcript, pp 170–186) With regard to price data that may be collected from utilities, some of it might be distorted due to demand side management (DSM) incentive programs, more specifically rebate programs. The price collected may not be the actual price of the equipment, but rather, the price after a rebate has been applied. (Steve Rosenstock, EEI, Transcript, pp 190)

In written comments, EEI stated that there is little correlation between manufacturer costs and retail prices, and that market surveys of customers, utilities, and contractors will likely provide the best information on retail prices. (EEI, #2) EMPA claimed that price data collected will likely not reflect conditions in the current market. (EMPA, #3) EMPA also stated that DOE should not shift the responsibility of collecting and providing data to interested parties.

ACEEE noted two possible data sources: a 1996 Xenergy report and Chris Neme at the Vermont Energy Investment Fund in Burlington, VT. (ACEEE, #5) OOE suggested that two methods are needed for deriving prices, each as a cross-check on the results of the other. (OOE, #7) One approach should be a ''mark-up'' of manufacturer costs which yield a range of retail prices. A market survey of equipment prices should be used as the second approach, as opposed to a survey of market experts trying to predict consumers' willingness to pay at various price levels. With regard to current market prices, PG&E believes that split system air conditioning equipment that exceeds 10 SEER are available at competitive prices with 12 SEER systems being readily available. (PG&E, #8)

For the pre-ANOPR Analysis, the Department did not attempt to conduct a comprehensive contractor or consumer survey of equipment prices. The primary reasons were the complexity of and the time needed for a comprehensive survey, and the short time frame allotted by the Department for publishing the Supplemental ANOPR. The Department will consider conducting a survey for any updates to the analyses conducted for the NOPR.

On November 30, 1998, however, the Department issued a **Federal Register** Notice (63 FR 65767) requesting comments on a proposal to survey retail prices for Central Air Conditioners and Heat Pumps. ARI responded to that request by submitting comments. The comments asserted that the proposed survey is woefully inadequate, given the number of variables involved. (ARI, #9) ARI suggested that, at a minimum, data on the following factors should be considered: (1) Three capacity sizes (1.5, 3, and 5 tons), (2) five efficiency levels (10, 11, 12, 13, 14 SEER), and (3) four classes (split and single package air-conditioner/c and heat pump). The survey should be weighted to reflect regional sales markets and a large number of manufacturers should be represented in the survey. In addition, there should be no reason to include questions on the impact of utility rebates, as they are dwindling rapidly.

The Department uses various assumptions about cost pass-through that are reflected in the price forecast approach. The output of this analysis is a table describing retail prices for each possible efficiency level, assuming that each level represents a new minimum efficiency standard. Consistent with the process rule, and building on the estimates generated by the various assumptions, projected retail prices are described within a range of uncertainty.

Purchase prices of baseline equipment were determined by estimating manufacturing costs and applying appropriate markups along the distribution chain. Markups were determined in two ways: through surveys of distributor (wholesale) and retail prices, and through publicly available financial reports. For about 90% of residential air conditioning equipment, the distribution chain includes manufacturers, distributors (wholesalers), and dealers (contractors). Equipment purchase prices are thus estimated as the product of manufacturing cost, manufacturer markup, distributor markup, dealer markup, and sales tax.

For the determination of markups via financial reports, it was assumed that product markups equal gross margin less pre-tax profit margin (earnings-before-taxes) and outbound freight of 6%, plus 1%. The baseline central air conditioner and heat pump units covered by this analysis typically have lower margins than other products handled by diversified companies. The values for markups given in the next paragraphs may change in future stages of analysis as the underlying data are improved and cross-checked.

Manufacturer Markup: Financial reports from five publicly traded air conditioner manufacturers, representing 75% of the market, were examined for a five-year period (1993–1997). Five-year average markups for the two most dependent on air conditioner sales were 1.18 and 1.17 respectively. The other three companies are more diversified and, as expected, exhibited higher markups—1.25, 1.24, and 1.18 respectively. A central value of 1.18 was chosen for the Price Analysis, with a range of 1.15 to 1.26, based on the lowest and highest markups for the five manufacturers for the five-year period.

Distributor Markup: Five-year average markups for the 500 members of the Air-conditioning and Refrigeration Wholesalers (ARW) were 1.37, the same as for 1997. This value was used for the analysis. However, since margins for after-market parts are substantially higher than margins for baseline equipment, the actual markup on baseline equipment is likely to be lower than the assumed value of 1.37. The markup value may be revised downwards based on future information.

Dealer Markup: Markups were calculated for contractors represented by the Air Conditioning Contractors of America (ACCA) and two contractor consolidators that focus on the residential market. Information used from ACCA covered ''residential and light commercial'' dealers, and was divided into new and retrofit services, with markups of 1.41 and 1.63, respectively. The weighted average markup for ACCA was 1.55 (based on 66 percent of all sales being retrofit sales), close to the markup of 1.54 for one of the contractor consolidators. The markup for the other consolidator was 1.38, but half of its revenues come from plumbing, electrical, and other services that typically have lower margins. A central value of 1.55 was chosen for the Price Analysis, with a range of 1.37 (based on information from ICF Consulting on equipment markups for direct replacement) to 1.63.

Sales Tax: In many cases, local and state sales taxes are applied to equipment purchases. Using 1997 state and local sales tax data and 1994 state unitary shipment data, the Department calculated a distribution of combined sales tax rates. Although the distribution revealed a small percentage of consumers at tax rates of 0% and 10%, the effective distribution was triangular with a mean of 6.7% and a range from 5% to 8%. This corresponds to a mean markup of 1.07 with a range from 1.05 to 1.08.

Overall Markup: Equipment purchase price is determined by multiplying manufacturer cost and overall markup. Mean values and ranges for the overall markup are the products of the mean values and ranges for manufacturer markup, distributor markup, dealer markup and sales tax. The mean overall markup is thus calculated as 2.68, with a range of 2.27 to 3.04.

iii. Payback Analysis (Distribution of Paybacks)

Payback is calculated based on the same inputs used for the LCC Analysis with the difference that the payback values are based on first year savings achieved after the standard takes effect. The output of the analysis is a distribution of payback periods. The mean payback period is also reported. Additional information is available in the LCC spreadsheet which is posted to the Department's web site. The data includes charts of cash flow taking into account the changing annual fuel prices.

iv. Rebuttable Payback

As discussed previously, EPCA established a rebuttable presumption that a standard is economically justified if the additional product purchase cost attributed to the standard is less than three times the value of the first year energy cost savings, which is equivalent to a three year simple payback. The calculation of rebuttable payback is based on single point-values instead of probability distributions used in the LCC analysis. For example, where a probability distribution of electricity prices are used in the distributional Payback Analysis, only the weighted-average value from the probability distribution of electricity prices is used for the determination of the Rebuttable payback.

Other than the use of single point-values, the most notable difference between the two payback analyses is the Rebuttable payback's reliance on the DOE test procedure to determine a central air conditioner's or heat pump's annual energy consumption. The DOE test procedure for central air conditioners and heat pumps in the cooling season uses the following expression to calculate the annual space-cooling energy consumption:

Space-Cooling Annual Energy Use =

$$(\text{Cooling Capacity} \div \text{SEER}) \times \text{Hours}$$

where the Hours equal 1000, the assumed annual operational hours of the space-cooling equipment.

The DOE test procedure for the heating season performance of heat pumps uses the following expression to calculate the annual space-heating energy consumption:

Space-Heating Annual Energy Use =

$$(\text{DHR} \div \text{HSPF}) \times 0.77 \times \text{Hours}$$

where DHR equals the design heating requirement (which for 3-ton cooling capacity heat pumps is typically 35,000 Btu/hr) and Hours equal 2080, the assumed seasonal operational hours of the space-heating equipment.

The annual space-cooling and heating energy consumption calculated based on the previous equations from the DOE test procedure are on the order of 50% greater than the weighted-average values from the 1993 RECS. This means that the payback value calculated from the DOE test procedure equations will be significantly lower than the average payback value calculated from the RECS analysis, for any standard level.

Rebuttable payback periods are first calculated between the new standard level being analyzed and each central air conditioner or heat pump efficiency being sold in the year 2006. The paybacks are then weighted and averaged according to the percentage of each equipment efficiency sold before a new standard is enacted. Rather than being based on probability distributions, single point values are used for the input variables. These values (e.g., operating hours per year) will correspond to those defined in the DOE test procedure. The result is a single-value of payback and not a probability distribution. The payback is calculated for the expected effective year of the standard (e.g., 2006). Examples and further details are presented in the Preliminary TSD.

Based on the most recently available shipments data from ARI (from 1994), Table 13 shows the markets shares by efficiency level for each of the four product classes being analyzed.

TABLE 13.—EFFICIENCY LEVEL MARKET SHARES

[In percent]

SEER	Split A/C	Split HP	Single package A/C	Single package HP
10	78.7	59.3	82.3	64.2
11	5.4	15.0	9.7	13.6
12	12.0	19.7	6.8	22.2
13	3.6	4.5	1.2	0.0
14	0.1	1.0	0.0	0.0
15	0.2	0.5	0.0	0.0

Because the shipment-weighted efficiencies of unitary air conditioners and heat pumps has remained essentially flat over the four year period from 1994 to 1997, the previous market shares in Table 13 for 1994 are assumed to be applicable for the year 2006. If available, data on a forecasted distribution of equipment efficiencies in the year 2006 will be used to refine these calculations for the NOPR Analysis.

2. Preliminary Results

a. General

Calculation of LCC captures the tradeoff between the increases in purchase price and reductions in operating expenses for increasing efficiencies of appliances. In addition, two other measures of economic impact are calculated: distributions of payback periods and a payback period calculated for purposes of the rebuttable presumption clause. The outputs of the LCC spreadsheet include probability distributions and single-point average values of the impacts for each energy efficiency level compared to the baseline. A distinct advantage of modeling based on probability distributions is that the percentage of consumers achieving LCC savings or attaining certain payback periods due to an increased efficiency standard can be identified. A variety of graphic displays can illustrate the implications of the analysis results. These include: (1) A cumulative probability distribution showing the percentage of U.S. households that would have a net saving by owning a more energy-efficient appliance, and (2) a chart depicting the variation in LCC for each efficiency level considered.

b. Product Specific

The following LCC results show the mean LCCs associated with the standard levels which were analyzed. In addition, the percent of households with reduced LCCs relative to current minimum efficiency equipment (10 SEER) are provided. LCC results are provided based upon the manufacturer cost estimates from the efficiency-level approach (section II C.1.b.i.) and the reverse engineering (section II.C.1.b.ii.). LCC results are presented for nominal 3-ton capacities for the four primary product classes, *i.e.,* split-type air conditioners, split-type heat pumps, single-package air conditioners, and single-package heat pumps (See Tables 14 to 17). Since the values of most inputs are uncertain and are represented by probability distributions of values rather than discrete values, the results presented in the Preliminary TSD (which describes the analytic results in greater detail) are also described by probability distributions.

TABLE 14.—SPLIT-TYPE AIR CONDITIONERS—LCC RESULTS

SEER	Source of manufacturing cost data			
	Industry		Reverse engineering	
	Mean LCC	Percent with lower LCC	Mean LCC	Percent with lower LCC
10	$4,837		$4,828	
11	4,827	39	4,786	48
12	4,886	31	4,770	45
13	5,229	12	4,931	27
14	5,659	6	5,246	15
15	6,052	4	5,456	11
16		2	5,533	11
17			5,672	10

TABLE 15.—SPLIT-TYPE HEAT PUMPS—LCC RESULTS

SEER / HSPF	Source of manufacturing cost data			
	Industry		Reverse engineering	
	Mean LCC	Percent with lower LCC	Mean LCC	Percent with lower LLC
10 / 6.8	$10,086		$10,001	
11 / 7.1	9,915	74	9,695	99
12 / 7.4	9,852	63	9,533	90
13 / 7.7	10,119	36	9,850	49
14 / 8.0	10,311	28	10,246	27
15 / 8.2	11,079	11	10,534	20
16 / 8.2			10,679	18

TABLE 16.—SINGLE PACKAGE AIR CONDITIONERS—LCC RESULTS

SEER	Source of manufacturing cost data			
	Industry		Reverse engineering	
	Mean LCC	Percent with lower LCC	Mean LCC	Percent with lower LCC
10	$5,341		$5,324	
11	5,429	20		
12	5,433	26	5,194	58
13	6,031	5	5,598	17
14	6,362	4		
15	6,921	2		

TABLE 17.—SINGLE PACKAGE HEAT PUMPS—LCC RESULTS

SEER	Source of manufacturing cost data			
	Industry		Reverse engineering	
	Mean LCC	Percent with lower LCC	Mean LCC	Percent with lower LCC
10 / 6.8	$10,025		$9,912	
11 / 7.1	9,906	61		
12 / 7.4	9,835	58	9,551	80
13 / 7.7	10,342	22		
14 / 8.0	10,425	21		
15 / 8.2	11,031	10		

Tables 18 to 21 show the median payback periods associated with each standard level. To note, the median value of a distribution has an equal number of payback periods that are greater than and less than the reported value. As with the LCC results, payback periods are provided based upon both the manufacturer cost estimates from the industry and from the reverse engineering analysis. Payback period results are presented for the four primary product classes; split-type air conditioners, split-type heat pumps, single-package air conditioners, and single-package heat pumps.

TABLE 18.—SPLIT-TYPE AIR CONDITIONERS—MEDIAN PAYBACK PERIODS

[In years]

SEER	Source of manufacturing cost data	
	Industry	Reverse engineering
11	13	10
12	15	11
13	41	20
14	80	35
15	137	43
16		46
17		49

TABLE 19.—SPLIT-TYPE HEAT PUMPS—MEDIAN PAYBACK PERIODS

[In years]

	Source of manufacturing cost data	
	Industry	Reverse engineering
11/7.1	6	1
12/7.4	8	3
13/7.7	13	10
14/8.0	17	17
15/8.2	31	21
16/8.4		22

TABLE 20.—SINGLE PACKAGE AIR CONDITIONERS—MEDIAN PAYBACK PERIODS

[In years]

SEER	Source of manufacturing cost data	
	Industry	Reverse engineering
11	20	
12	17	8
13	84	30
14	133	
15	559	

TABLE 21.—SINGLE PACKAGE HEAT PUMPS—MEDIAN PAYBACK PERIODS

[In years]

SEER/HSPF	Source of manufacturing cost data	
	Industry	Reverse engineering
11/7.1	8	
12/7.4	9	5
13/7.7	20	
14/8.0	20	
15/8.2	31	

Tables 22 to 25 show the simple paybacks for purposes of the rebuttable presumption clause. This means test procedure assumptions are followed for central air conditioners and heat pumps.

TABLE 22.—SPLIT-TYPE AIR CONDITIONERS—SIMPLE PAYBACK

[In years]

SEER	Source of manufacturing cost data	
	Industry	Reverse engineering
11	6.2	5.0
12	7.6	5.4
13	13.7	7.8
14	20.9	12.7
15	26.8	14.7
16		14.6
17		15.4

TABLE 23.—SPLIT-TYPE HEAT PUMPS—SIMPLE PAYBACK

[In years]

SEER/HSPF	Source of manufacturing cost data	
	Industry	Reverse engineering
11/7.1	3.2	0.4
12/7.4	4.2	1.8
13/7.7	6.8	5.6
14/8.0	8.0	8.8
15/8.2	13.8	10.5
16/8.4		10.8

TABLE 24.—SINGLE PACKAGE AIR CONDITIONERS—SIMPLE PAYBACK

[In years]

SEER	Source of manufacturing cost data	
	Industry	Reverse engineering
11	9.9	
12	8.5	3.8
13	21.2	11.2
14	25.2	
15	35.8	

TABLE 25.—SINGLE PACKAGE HEAT PUMPS—SIMPLE PAYBACK

[In years]

SEER/HSPF	Source of manufacturing cost data	
	Industry	Reverse engineering
11/7.1	4.3	
12/7.4	4.6	2.7
13/7.7	9.7	
14/8.0	9.2	
15/8.2	13.7	

E. Preliminary National Impacts Analyses

The National Impacts Analysis assesses the net present value (NPV) of total consumer LCC, average consumer payback, NES, and indirect employment impacts. Each of the above are determined for selected 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 standards rulemakings and tailored to each specific appliance rulemaking. NES spreadsheets for central air conditioners and heat pumps are posted to the Department's web site. A preliminary assessment of the aggregate impacts at the national level has been conducted for this Supplemental ANOPR.

Analyzing impacts of Federal energy-efficiency standards requires a comparison of projected U.S. residential energy consumption without standards (baseline case) and with standards. The baseline case includes the mix of efficiencies of appliances being sold at the time the standard becomes effective. The forecasts contain projections of unit energy consumption of new appliances, annual appliance shipments, and prices of purchased appliances. The differences between the baseline and standards cases represent the energy and cost savings. Depending on the method used for sales projections, the sales under a standards case projection may differ from those of a baseline case projection.

The Department calculated national energy consumption for each year, beginning with the expected effective date of the standards, for the base case and for each candidate standards level using two methods, *i.e.,* simple spreadsheets, and multiplication of shipment forecasts by unit energy savings. Spreadsheets for shipments analysis are posted to the Department's web site. Energy consumption and savings are estimated based on site energy (kWh of electricity), then the electricity consumption and savings are converted to source energy. The differences in annual energy consumption between the base case and standards case were aggregated to arrive at cumulative energy savings through the year 2030.

DOE agrees with the Advisory Committee's recommendation that the assumption of a constant site to source-energy conversion factor should be dropped in favor of a conversion factor that changes from year to year. The conversion factor would be calculated for each year of the analysis based on the generating capacity displaced and the amount of site energy saved (see the following detailed procedure). For future conversion factors, DOE proposes to use the following method:

(1) Start with an integrated projection of electricity supply and demand (*e.g.,* the National Energy Modeling System (NEMS) AEO reference case), and extract the source energy consumption.

(2) Estimate projected energy savings due to possible standards for each year (*e.g.,* using the NES spreadsheet).

(3) Feed these energy savings back to NEMS as a new scenario, specifically a deviation from the reference case, to obtain the corresponding source energy consumption.

(4) Obtain the difference in source energy consumption between this standard level scenario and the reference case.

(5) Divide the source energy savings in Btu, adjusted for class specific transmission and distribution losses, by the site energy savings in kilowatt-hours to provide the time series of conversion factors in Btu per kilowatt-hour.

The resulting conversion factors will change over time, and will account for the displacement of generating sources. Furthermore, the NES spreadsheet models will 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 replacing this column of numbers.

1. National Energy Savings (NES) Spreadsheet Model

a. General

In order to make the analysis more accessible and transparent to all stakeholders, the Department has previously prepared spreadsheet models using Microsoft Excel in Windows 95 for other appliances to forecast energy savings and to demonstrate how improvements in efficiency can be accounted for over time. These models, the NES spreadsheets, are specific applications of a common model structure to each appliance, and a model was tailored to the case of central air conditioners and another for the case of heat pumps. These same NES spreadsheets were also used to forecast net present value (NPV). These spreadsheets are posted to the Department's web site.

The NES spreadsheets are used to calculate the NES, and the national economic costs and savings from new standards. Input quantities can be changed within the spreadsheet. Unlike the LCC Analysis, the NES Spreadsheet does not use probability distributions for inputs or outputs. Both EEI and OOE stated that the NES Analysis should use a range of values rather than single point-values. Specifically, EEI stated that a range of equipment costs should be used to determine NES and net present values while OOE presumes that distributional inputs will be used to depict regional differences. (EEI, #2; OOE, #7) In order to address these concerns, the Department will conduct sensitivity analyses as needed for the NOPR Analysis by running scenarios on the input variables of interest.

One of the more important components of any estimate of the impact of future standards is shipments. Forecasts of shipments for the base case and the standards case need to be obtained as an input to the NES. The Department developed a base case forecast of product shipments in the absence of new standards. For all candidate standards levels, shipment forecasts are needed to calculate the national benefits of standards and to calculate the future cash flows of manufacturers. There are a variety of methods available for projecting shipments. A sophisticated accounting model was used by the Department and run to determine shipment scenarios for each energy efficiency level.

Other quantities in the NES spreadsheet are: energy price projections, including an analysis of consumer marginal electricity rates (*See* Section II.D.1.a); effective date of the standard (start year); discount rate and the year of the NPV (1999); manufacturing cost; total installed cost; baseline energy use; lifetime; and the conversion factor from site to source energy.

An industry representative requested that the impact of existing minimum efficiency standards be calculated in order to determine whether the existing standards are indeed cost-effective. (David Lewis, Lennox International, Transcript, pp 313) The Department has not made any attempt to determine the cost-effectiveness of the existing minimum efficiency standards. The Department believes that such an analysis would not materially contribute to a decision whether to adopt a more stringent standard. Rather, the energy savings and NPV are calculated from the expected date any new standard level would take effect to the year 2030. Both individual year and cumulative data are generated. Output charts and tables provide cumulative energy savings, the cost and savings per year (in a chart), and the cost and NPV due to standards.

b. Product Specific

i. Inputs to NES Analysis

Table 26 summarizes the inputs used in the NES model. The NES model uses the same basic data as the LCC model for energy use and cost of equipment, except that shipment weighted-average values (based on the shipment and energy-efficiency distribution forecasts) are used instead of distributions. As with the LCC Analysis, two sets of results, including forecasts of shipments, energy savings, and net present value (NPV), were calculated based on two different sets of costs (industry data and reverse engineering) associated with increasing efficiency.

TABLE 26.—SUMMARY OF NES MODEL INPUTS

Parameter	Data description
Shipments	Output from Shipment Model.
Total installed Consumer Cost	Average value for the baseline and each standard level. From LCC Analysis.
Repair and Maintenance Costs	Average values for the baseline and each standard level. From LCC Analysis.
Historical Efficiencies	Shipment-weighted efficiency data (SEER) from the Air-Conditioning and Refrigeration Institute for the years 1976–1997.
Future Efficiency Trend	For the years 1998 to the assumed effective date of the new standard (2006), shipment-weighted efficiencies are assumed to remain constant at the shipment-weighed efficiency level in 1997. For years beyond the assumed effective date of the new standard, shipment-weighted efficiencies are assumed to equal the new standard level.
Unit Annual Energy Consumption	Based on the weighted-average annual energy consumption and efficiency from LCC Analysis. To estimate the representative annual energy consumption of a central air conditioner or heat pump for any given year, the ratio of the RECS weighted-average efficiency to the efficiency level in that year is multiplied by the RECS weighted-average annual energy consumption.
Electricity Prices	Based on the weighted-average marginal electricity price determined from RECS93 in the LCC Analysis.
Escalation of Electricity Prices	1999 EIA *AEO* forecasts (to 2020) and extrapolation from 2020 to 2030.
Electricity Site-to-Source Conversion	Conversion varies yearly and is provided by the 1999 Annual Energy Outlook (a time series conversion factor; includes electric generation transmission and distribution losses).
Discount Rate	7% real.
Present Year	Future expenses are discounted to year 1999.

Both EEI and EMPA provided comments on the type of electricity price that should be used in the analysis. EEI warned that energy savings will decrease as a result of dropping energy prices, and that the *1998 AEO* electricity price forecasts do not decline rapidly enough, since factors resulting from deregulation are not accounted for. Both EEI and EMPA stated that marginal rather than average electricity prices should be used in all calculations. (EEI, #2; EMPA, #3) As noted in Table 26 and as discussed earlier in the LCC Analysis (section II D.1.b.i.), the Department used the most recent forecasts from the *1999 AEO* to predict the trend in both average and marginal electricity prices. In addition, the NES spreadsheets can be run with price forecasts from the GRI. The Department believes these forecasts are the most reliable available to predict future energy trends. With regard to marginal energy prices, the Department is using mean marginal prices to calculate energy savings.

EEI also warned that energy savings from higher SEERs could be lower in hot and humid climatic regions, where EER is a better indicator of equipment performance. (EEI, #2) Although the performance of equipment can vary depending on climatic conditions, the Department believes that SEER will provide the best indicator of annual energy use in all climates. The annual energy consumption values from the 1993 RECS, which the NES spreadsheet uses as the basis for determining the energy savings from higher SEER standards, accounts for regional variations in energy use.

EEI stated that diversity factors must be taken into account when calculating NES, as not all air conditioners are on at the same time. Utility load factors should also be addressed. (Steve Rosenstock, EEI, Transcript, p 272; EEI, #2). Diversity and utility load factors are not accounted for in the determination of NES. Rather, the NES are passed through to the Utility Impact Analysis which will establish the impacts of the savings on utility generation and distribution. The model to be used in the Utility Analysis (NEMS-BRS) accounts for diversity and utility load factors when determining the impacts on the utility industry. NEMS–BRS is a variant of U.S. DOE/EIA's NEMS and is named as such for two reasons: (1) The Utility Analysis to be performed entails some minor code modifications and (2) the model will be run under various policy scenarios that will be variations on DOE/EIA assumptions. The name NEMS-BRS refers to the model to be used for the Utility Analysis (BRS is DOE's Building Research and Standards office). NEMS was used by DOE/EIA to produce the 1999 AEO, and NEMS-BRS is used to provide some key equivalent inputs to the standards analysis.

ii. Shipments Model

The Department chose an accounting model method to prepare shipment scenarios for baseline (10 SEER) and five standard levels (11 through 15 SEER) for central air conditioners and heat pumps. The model tracks the stocks and purchases of each type of central air conditioner and heat pump. Events and consumer decisions influence how the stock and supply of central air conditioner and heat pump systems flow from one category to another. Decisions that are economically influenced are modeled with econometric equations.

OOE supports the use of the accounting method for forecasting shipments, but stated that thorough discussions will be required in order to quantify the impacts of non-regulatory programs and market trends. (OOE, #7) The Department reviewed information from parties involved in market-based initiatives for increasing the sales of high-efficiency models but was unable to determine any quantifiable measure of how these programs impact product efficiencies on a national basis. Thus, the impact of market-based initiatives was not incorporated into the baseline and standard level forecasts.

The model is organized into three classes of elements: Stocks, events, and decisions. Stocks of central air conditioners and heat pumps are divided into *ownership categories*, and units are assigned to age categories. Events are things that happen to stocks independent of economic conditions, i.e., breakdowns requiring repair or replacement. Decisions are consumer reactions to market conditions, e.g., whether to repair or replace equipment, or to buy a house with or without an air conditioner or heat pump. Consumer purchase decisions are categorized by *market segments*. Decision trees are used to describe consumer choices for purchases and repairs. A *logit probability model* simulates consumer purchase decisions that are based on equipment price, operating costs, and income level.

Ownership Categories: Households are first divided into central air conditioner and heat pump markets, then the two markets are further divided into four different ownership categories, including (1) new housing, (2) existing housing with a regular central air conditioner or heat pump (*i.e.*, equipment has not been repaired to extend its life), (3) housing without a central air conditioner or heat pump, and (4) housing with an extended life central air conditioner or heat pump (*i.e.*, equipment repaired to extend its life). The population of central air conditioner and heat pump units in each ownership category are referred to as the *stock of* central air conditioner and heat pump units of that category. Accounting equations relate annual changes in stocks to activities in the various market segments.

Market Segments: Central air conditioner and heat pump purchases are divided into five market segments:

- *Net New Housing Market:* Net increase in the housing stock forces the purchase of new central air conditioner and heat pump systems.
- *Early (Discretionary) Replacement Market:* About 29% of central air conditioner and heat pump owners replace the existing systems before the systems break down because they want an updated model, because of remodeling, or for other miscellaneous reasons.
- *Regular Replacement Market:* Most central air conditioner and heat pump purchases are to replace an existing system that has broken down after completion of its useful life.
- *Extra Repair Market:* Since replacement of central air conditioner and heat pump systems is costly, a few consumers will rebuild or repair a malfunctioning system (thus extending its lifetime) rather than purchasing a new system. Eventually, even extended-life central air conditioner and heat pump systems are replaced.
- *Homes without an air conditioner or heat pump system:* A few households without a central air conditioner or heat pump system will purchase them and become new central air conditioner or heat pump owners.

Events and decisions (e.g., the probability that an existing central air conditioner has a problem and the course of action taken by the consumer) are modeled separately for each market segment.

Logit Probability Model: The logit probability of purchase model is used to estimate the impact of standards-induced price and features changes on consumer decisions. The model accounts for consumer responsiveness to purchase price, operating costs, and income. Coefficients for the responsiveness to these three factors were developed for each of the market segments, based on the results of empirical research on consumer purchase behavior. The probabilities are applied to equations that govern activities in the various market segments.

Table 27 summarizes the various inputs and sources of the central air conditioner and heat pump shipment model.

TABLE 27.—SUMMARY OF SHIPMENT MODEL INPUTS

Parameter	Data description/source
Data for New Housing Starts	Census Bureau data on new housing construction.
Data for Early Replacement Market	1990 ASHRAE technical paper entitled ''Heat Pump Life and Compressor Longevity in Diverse Climates''. In the paper, 29% of consumers in 1987 replaced their equipment for reasons other than unit failure.
Data for Regular Replacement Market	1990 ASHRAE technical paper entitled ''Heat Pump Life and Compressor Longevity in Diverse Climates''. Survival functions for total system life and original compressor life are presented. The compressor survival function was used to establish the probability that a system has problems while the difference between the two survival functions was used to establish the probability of repair vs. replacement.
Data for Extra Repair Market	1990 ASHRAE technical paper entitled ''Heat Pump Life and Compressor Longevity in Diverse Climates''. Total system survival function was used establish the probability of extended or extra repair.
Data for Homes without an air conditioner or heat pump.	March 29, 1993 issue of the Air-Conditioning, Heating and Refrigeration News. In 1992, 14% of central air conditioner and heat pump shipments went to non-owner households.
Elasticities	Purchase Price, Operating cost, and Income elasticities—from The ORNL Engineering-Economic Model of Residential Energy Use, Oak Ridge National Laboratory, 1978.
Source of Household Income	EIA, *1999 AEO.*

This shipments model allows appliance saturations to be expressed as a function of consumer price and operating cost in order to capture the effect of those two variables on future shipments. The Department prepared consumer price and operating cost elasticities to calibrate appliance forecasts to historical shipments. These and other features of the model allow it to provide estimates that are consistent with the recent history of central air conditioner and heat pump shipments, market structure, and consumer preferences.

Drawbacks of this method include: (1) Saturation of units in new and stock households must be forecasted, (2) housing starts must be forecasted (although the AEO does provide readily available forecasts), and (3) retirement of units must be based upon assumptions regarding lifetimes.

Unlike the LCC model, the shipments model does not use probability distributions of values for inputs. While the shipment models uses the same basic input data as the LCC model for energy use and cost of equipment, the model uses shipment weighted-average values instead of probability distributions.

Because NES are dependent on shipments (which, in turn, are dependent on equipment purchase price), the Department prepared two sets of shipments forecasts, one based on manufacturer cost data for increases in efficiency levels and the other based on cost data from the reverse engineering methodology, both of which are presented in the Preliminary TSD.

iii. National Net Present Value

Net present value (NPV) is the sum over time of discounted net savings. The national NPV of each candidate standards level is the difference between the base case national average LCC and the national average LCC in the standards case.

Using the NES model, NPV was calculated from projections of national expenditures for central air conditioners and heat pumps, including total installed consumer cost and operating expenses. Future costs and savings were discounted to the present with a discount factor, which was calculated from the discount rate and the number of years between the present (year to which the sum is being discounted) and the year in which the costs and savings occur.

The inputs for the determination of national NPV were detailed in the discussion of the NES model. Like the NES results, two sets of NPV results were prepared; one based on industry-provided manufacturer costs and the other on the reverse engineering data.

2. Preliminary Results

a. General

The Department calculated the national energy consumption by multiplying the number of central air conditioners and heat pumps (by vintage) by the unit energy consumption (also by vintage). Vintage is the age of the equipment (varying from one to twenty four-years). National annual energy savings is the difference between national energy consumption at the base case (without new standards) and each standards case. Cumulative energy savings are the sum of the annual NES over several time periods (*e.g.,* 2006–2010, 2006–2020, and 2006–2030).

National economic impacts are calculated from the energy savings. The primary metric for measuring national economic impact is NPV. The NPV can be expressed by the following equation:

$$NPV = PVS - PVC$$

Where PVS equals the present value of operating cost savings (including electricity, repair, and maintenance cost savings) and PVC equals the present value of increased equipment costs (including equipment price and installation price). Another way of describing NPV is that it is the difference between the LCCs (for all appliances sold) with and without standards.

In NPV, costs are calculated as the product of (1) the difference in the purchase price between the base case and standards case and (2) the annual sales volume in the standards case. Since costs of the more-efficient equipment purchased in the standards case are higher than those of equipment purchased in the base case, price increases appear as negative values in the NPV.

Monetary savings are typically exhibited as decreases in operating costs associated with the higher energy efficiency of appliances purchased in the standards case compared to the base case. Total operating cost savings is the product of savings per unit and the number of units of each vintage surviving in a particular year. Savings appear as positive values in the NPV.

Net savings each year are calculated as the difference between Total Operating Cost Savings and Total Equipment Costs. The savings are calculated over the life of the appliance, accounting for the differences in yearly energy rates. Future annual costs and savings are discounted to the present time and summed. 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 can be expressed in another form, as the benefit/cost ratio. The benefit is the savings in decreased operating expenses (including electricity, repair, and maintenance), while the cost is the increase in the purchase price (including equipment and installation price) due to standards relative to the base case. When the NPV is greater than zero, the benefit/cost ratio is greater than one.

b. Product Specific

Tables 28 to 31 show the forecasted NES for the four primary product classes at each of the five efficiency levels analyzed (11 through 15 SEER). The results shown are based on a single shipment weighted average (SWA) cost instead of a cost distribution.

TABLE 28.—SPLIT-TYPE AIR CONDITIONERS: CUMULATIVE NES IMPACTS FROM 2006 TO 2030

[Quads]

SEER	Source of manufacturer cost data	
	Industry	Reverse Engineering
Base Case [1]	24.3	24.3
11	0.7	0.7
12	2.6	2.5
13	4.3	4.1
14	5.8	5.6
15	7.0	6.7

[1] Values for Base Case are the cumulative national energy consumption from 2006 to 2030.

TABLE 29.—SPLIT-TYPE HEAT PUMPS: CUMULATIVE NES IMPACTS FROM 2006 TO 2030

[Quads]

SEER/HSPF	Source of manufacturer cost data	
	Industry	Reverse engineering
Base Case [1]	27.8	27.8
11/7.1	0.1	0.0
12/7.4	1.3	1.1
13/7.7	2.9	2.8
14/8.0	4.3	4.4
15/8.2	5.8	5.6

[1] Values for Base Case are the cumulative national energy consumption from 2006 to 2030.

TABLE 30.—SINGLE PACKAGE AIR CONDITIONERS: CUMULATIVE NES IMPACTS FROM 2006 TO 2030

[Quads]

SEER	Source of manufacturer cost data	
	Industry	Reverse engineering
Base Case [1]	3.8	3.8
11	0.1	
12	0.4	0.4
13	0.7	0.7
14	0.9	
15	1.1	

[1] Values for Base Case are the cumulative national energy consumption from 2006 to 2030.

TABLE 31.—SINGLE PACKAGE HEAT PUMPS: CUMULATIVE NES IMPACTS FROM 2006 TO 2030

[Quads]

SEER/HSPF	Source of manufacturer cost data	
	Industry	Reverse engineering
Base Case [1]	4.7	4.7
11/7.1	0.0	
12/7.4	0.2	0.2
13/7.7	0.5	
14/8.0	0.7	
15/8.2	1.0	

[1] Values for Base Case are the cumulative national energy consumption from 2006 to 2030.

Tables 32 to 35 show the national NPVs for the four primary product classes at each of the five efficiency levels analyzed (11 through 15 SEER).

TABLE 32.—SPLIT-TYPE AIR CONDITIONERS: CUMULATIVE NET PRESENT VALUE IMPACTS FROM 2006 TO 2030

[In billions of 1998 dollars]

SEER	Source of manufacturer cost data	
	Industry	Reverse engineering
11	−0.3	0.1
12	−2.8	−0.1
13	−7.5	−1.8
14	−156	−8.4
15	−22.0	−12.1

TABLE 33.—SPLIT-TYPE HEAT PUMPS: CUMULATIVE NET PRESENT VALUE IMPACTS FROM 2006 TO 2030

[In billions of 1998 dollars]

SEER/HSPF	Source of manufacturer cost data	
	Industry	Reverse engineering
11/7.1	0.0	0.1
12/7.4	−0.6	0.5
13/7.7	−1.6	−1.5
14/8.0	−2.8	−4.3
15/8.2	−8.1	−6.2

TABLE 34.—SINGLE PACKAGE AIR CONDITIONERS: CUMULATIVE NET PRESENT VALUE IMPACTS FROM 2006 TO 2030

[In billions of 1998 dollars]

SEER	Source of manufacturer cost data	
	Industry	Reverse engineering
11	−0.2	
12	−0.3	0.2
13	−1.9	−1.0
14	−2.8	
15	−4.3	

TABLE 35.—SINGLE PACKAGE HEAT PUMPS: CUMULATIVE NET PRESENT VALUE IMPACTS FROM 2006 TO 2030

[In billions of 1998 dollars]

SEER/HSPF	Source of manufacturer cost data	
	Industry	Reverse engineering
11/7.1	0.0	
12/7.4	−0.1	0.1
13/7.7	−0.6	
14/8.0	−0.6	
15/8.2	−1.3	

3. Indirect Employment Impacts

a. General

The July 1996 Process Rule includes employment impacts among the factors to be considered in selecting a proposed standard. The Process Rule states a presumption against any proposed standard level that would cause significant plant closures or losses of domestic employment.

The Department estimates the impacts of standards on employment for appliance manufacturers, relevant service industries, energy suppliers, and the economy in general. Employment impacts are separated into indirect and direct impacts. Direct employment impacts would result if standards lead to a change in the number of employees at manufacturing plants and related supply and service firms. Direct impacts are estimated in the Manufacturer Sub-Group Analysis (section G.2).

Indirect impacts are impacts on the national economy other than in the manufacturing sector being regulated. Indirect impacts may result from both expenditures shifting among goods (substitution effect), and income changing, which will lead to a change in overall expenditure levels (income effect). Indirect employment impacts from standards are defined as net jobs eliminated or created in the general economy as a consequence of increased spending on the purchase price of appliances and reduced household spending on energy.

New appliance standards are expected to increase the purchase price of appliances (retail price plus sales tax, and installation). The same standards are also expected to decrease energy consumption, and therefore reduce household expenditures for energy. Over time, the increased purchase price is paid back through energy savings. The savings in energy expenditures may be spent on other items. Using an input/output model of the U.S. economy, this analysis seeks to estimate the effects on different sectors, and the net impact on jobs. National impacts will be estimated for major sectors of the U.S. economy in the NOPR. Public and commercially available data sources and software will be utilized to estimate employment impacts. At least three scenarios will be analyzed to bound the range of uncertainty in future energy prices. All methods and documentation will be made available for review.

b. Product Specific

The Department of Energy's Office of Building Technologies and State Programs (BTS) has developed a spreadsheet model (IMBUILD) that could be used to analyze indirect employment impacts. IMBUILD is a special-purpose version of the Impact Analysis for Planning (IMPLAN) national input-output model which specifically estimates the employment and income effects of building energy technologies. IMPLAN was developed originally by the U.S. Forest Service in cooperation with the Federal Emergency Management Agency (FEMA) and the Bureau of Land Management (BLM) to assist the Forest Service in land and resource management planning. IMBUILD is an economic analysis system that focuses on those sectors most relevant to buildings, and characterizes the interconnections among 35 sectors as national input-output matrices. The IMBUILD output includes employment, industry output, and wage income. Changes in expenditures due to appliance standards can be introduced to IMBUILD as perturbations to existing economic flows and the resulting net national impact on jobs by sector can be estimated. Additional detail is provided in the Preliminary TSD.

OOE stated that they are not familiar with this type of analysis and believe that DOE should utilize specialists that may exist at the Department of Commerce or the Department of Labor. (OOE, #7) The Department intends to use IMBUILD in its analysis of indirect employment impacts due to its relatively long history of being used as a tool (in its original form as IMPLAN) for assessing economic impacts. Although neither the Departments of Commerce or Labor were involved in the development of IMPLAN, the model was based on use of the Commerce Department's make-and-use tables, input-output model of the U.S. economy, and price deflators; and use of the Labor Department's schedule of wages. Consequently, DOE believes IMBUILD is a sound method for analyzing indirect employment impacts. IMBUILD, in its original form as IMPLAN, has been used since 1979 by a wide variety of government and private agencies including FEMA and BLM in conducting economic impact analyses.

F. Consumer Analyses

The Consumer Analysis evaluates impacts on any identifiable groups, such as consumers of different income levels, who may be disproportionately affected by any national energy efficiency standard level.

The Department plans to evaluate variations in regional energy prices, variations in energy use and variations in installation costs that might affect the NPV of a standard to consumer sub-populations. To the extent possible, the Department will obtain estimates of the variability of each input parameter and consider this variability in its calculation of consumer impacts. The analysis is structured to answer questions such as: How many households are better off with standards and by how much? How many households are not better off and by how much? The variability in each input parameter and likely sources of information will be discussed with stakeholders.

Variations in energy use for a particular appliance depend on factors such as climate, type of household, and people in household. Annual energy use can be estimated by a calculation based on an accepted test procedure or it can be measured directly in the field. The Department plans to perform sensitivity analyses to consider how differences in energy use will affect sub-groups of consumers.

The impact on consumer sub-groups will be determined using the LCC spreadsheet model. Details of this model are explained in the LCC section of the Preliminary TSD.

1. Consumer Sub-Group Analysis

a. General

The Department will be sensitive to increases in the purchase price to avoid negative impacts to identifiable population groups, such as consumers of lower income levels. Additionally, the Department will assess the likely impacts of an increased purchase price on product sales and fuel switching.

b. Product Specific

For consumers, one measure of economic impact is the first cost of the product. The Department will analyze first costs to determine their impacts on consumer subgroups. The Department will be especially attentive to the need to avoid negative impacts on population groups such as low-income households. Increased first costs to consumers resulting from standards are especially important for lower-income consumers, since this group is most sensitive to price increases. For lower-income consumers, increases in first costs for a product can preclude the purchase of a new model of that product. As a result, some consumers may retain products past their useful life, or purchase older, used appliances. These older products are generally less efficient, and their efficiency may deteriorate if they are retained beyond their useful life. Increases in first cost can also preclude the purchase and use of a product altogether resulting in a potentially large loss of utility.

OOE commented that with regard to first-cost increases on low-income households, the number of low-income households affected by any new standards should first be determined (OOE, #7). The Department seeks input on identifying the potential impacts of a large first-cost increase on consumers (affordability, financing, and on other financial issues), and on methods and data the Department could use in conducting its analysis. The Department also seeks input on methods the Department might use to assess the likely impacts of first-cost increases on product sales and fuel switching.

2. Consumer Participation

a. General

The Department seeks to inform and involve consumers and consumer representatives in the process of developing standards. This includes notification of consumer representatives during the rulemaking process and where appropriate, seeking direct consumer input.

For all products, consumer input is important for several related but separate analytical tasks. First, consumer preferences should be understood prior to determining product classes in order to preserve product utility. Second, assessing the impact of changes in first cost may require direct consumer participation from affected consumer sub-groups (particularly low-income households). Finally, consumer input is useful to ensure that life-cycle costs are accurately estimated for relevant subgroups of consumers. To assess consumer impacts, the Department usually combines life-cycle cost modeling and direct consumer input.

The advisory committee sub-group on consumer issues has suggested appropriate means of obtaining consumer input, including: (1) Using focus groups, (2) conducting surveys, (3) conducting demonstration projects, (4) conducting marketing analysis, and, (5) researching existing literature from voluntary programs. In seeking this information, the advisory committee sub-group emphasized the need for the Department to obtain information from statistically significant sample sizes of all relevant consumer categories.

b. Product Specific

OOE recommended that the Department first investigate the actual level of consumer input or choice involved in the purchase of these systems before spending any time putting resources into surveying consumers about first cost increases. (OOE, #7) OOE warned that HVAC contractors, rather than consumers, may have greater decision-making power regarding the purchase of systems.

G. Manufacturer Impact Analysis

The Manufacturer Impact Analysis estimates the financial impact of standards on manufacturers and calculates impacts on competition, employment, and manufacturing capacity.

Prior to initiating the detailed Manufacturing Impact Analysis, the Department will prepare an approach document and have it available for review. While the general framework will serve as a guide, the Department intends to tailor the methodology for each rule on the basis of stakeholder comments. The document will outline procedural steps and outline issues for consideration. Three important elements of the approach consist of the preparation of an industry cash flow, the development of a process to consider sub-group cash flow, and the design of an guide to interview manufacturers and others in gathering information.

The policies outlined in the Process Rule required substantial revisions to the analytical framework to be used in performing Manufacturer Impact Analysis for each rulemaking. In the approach document, the Department will describe and obtain comments on the methodology to be used in performing the manufacturer impact analyses. The manufacturer impact analyses will be conducted in three phases. Phase 1 consists of two activities, namely, preparation of an industry characterization and identification of issues. Phase 2 has as its focus the larger industry, and in this phase, the GRIM will be used to perform an Industry Cash Flow Analysis. Phase 3 involves repeating the process described in Phase 2 (the Industry Cash Flow Analysis) but on different sub-groups of manufacturers. Phase 3 also entails determining additional impacts on competition, employment, and manufacturing capacity.

1. Industry Characterization (Phase 1)

a. General

Phase 1 of the Manufacturer Impact Analysis consists of collecting pertinent financial and market information. This activity involves both quantitative and qualitative efforts. Data gathered will include market share, corporate operating ratios, wages, employment, and production cost ratios. These data are incorporated into the Engineering Analysis in the estimation of equipment production costs and distribution markups. Sources of information include reports published by industry groups, trade journals, and the U.S. Bureau of Census, and copies of SEC 10–K filings.

b. Product Specific

The Department collected central air conditioner manufacturer information to support the Engineering Analysis. This included manufacturer market shares, markups along the distribution chain, and typical ratios for labor, materials, and overhead. This information appears throughout the Preliminary TSD that accompanies this Supplemental ANOPR.

2. Industry Cash Flow (Phase 2)

a. General

A change in standards affects the analysis in three distinct ways. Standards at higher levels will require additional investment, will raise production costs, and will affect revenue through higher prices and, possibly, lower quantities sold. The Department will quantify these changes by performing an Industry Cash Flow Analysis using the GRIM. Usually this analysis will use manufacturing costs, shipments forecasts, and price forecasts developed for the other analyses. Financial information, also required as an input to GRIM, will be developed based on publicly available data and confidentially submitted manufacturer information.

The GRIM Analysis uses a number of factors: Annual expected revenues; manufacturer costs such as 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 from before implementation of standards and continuing explicitly for several years after implementation. The measure of industry net present values are calculated by discounting the annual cash flows from the period before implementation of standards to some future point in time. The Preliminary TSD describes the GRIM's operating principles.

b. Product Specific

The Industry Cash Flow Analysis uses average manufacturing costs (with uncertainty) as described in the Engineering Analysis (section II.C.2), shipments forecasts as described in the Preliminary National Impact Analysis (section II.E.1), and price forecasts as described in the LCC and Payback Analysis (section II.D.1.) Financial information, also required as an input to the GRIM, is based on publicly available data and confidentially submitted manufacturer information. The cash flow analysis will be distributed to interested parties prior to the workshop to be held after publication of this Supplemental ANOPR.

In Phase 2, the Department intends to expand the Phase 1 analysis to include a Cash Flow Analysis covering, in aggregate, the firms that manufacture residential central air conditioning equipment. The data gathered in Phase 1 will be augmented with data from additional public and private sources.

These include shipment projections developed for the NES Analysis and interviews with individual manufacturers. The GRIM will estimate the potential effects of new standards on industry cash flow, net present value, capacity, and employment. Scenarios will include both HCFC–22 and hydro-fluoro-carbon (HFC) refrigerants, HFC–410A. Other considerations include imports and exports, uncertainty, and cumulative regulatory burden.

An industry representative stated that his company would be very unlikely to provide proprietary cost data directly to DOE or its contractors. (Jim Crawford, Trane, Transcript, p 134). The Oregon Office of Energy (OOE) warned that an Industry Cash Flow Analysis should be internally consistent with data used in other analyses (OOE, #7). The Department currently is seeking further input from stakeholders on whether additional scenarios are needed, and on the general appropriateness of the data sources and methods.

3. Manufacturer Sub-Group Analysis (Phase 3)

a. General

Assessment of impacts on sub-groups of manufacturers is Phase 3 of the Manufacturing Impact Analysis. Using industry ''average'' cost values is not adequate for assessing the variation in impacts among sub-groups of manufacturers. Smaller manufacturers, niche manufacturers or manufacturers exhibiting a cost structure largely different from industry averages could be more negatively affected. Ideally, the Department would consider the impact on every firm individually. In highly concentrated industries this may be possible. In industries having numerous participants, the Department will use the results of the industry characterization to group manufacturers exhibiting similar characteristics. The financial analysis of the ''prototypical'' firm performed in the Phase 2 industry analysis can serve as a benchmark against which manufacturer sub-groups can be analyzed.

The manufacturing cost data collected for the Engineering Analysis will be used to the extent practical in the sub-group impact analysis. To be useful, however, this data should be disaggregated to reflect the variability in costs between relevant sub-groups of firms.

The Department will conduct detailed interviews with as many manufacturers as is possible to gain insight into the potential impacts of standards. During these interviews, the Department will solicit the information necessary to evaluate cash flows and to assess competitive, employment and capacity impacts. Firm-specific cumulative burden will also be considered.

b. Product Specific

In order to conduct a Manufacturer Sub-Group Analysis, it will be necessary to define representative sub-groups and conduct separate Cash Flow Analysis for each. For example, one option consists of conducting separate cash flows for all manufacturers. Another option, could entail conducting Cash flow Analysis only for those manufacturers which believe their impacts are more severe then industry average.

The Department intends to examine two sub-groups: high-volume manufacturers and low-volume manufacturers. A ''strawman'' GRIM Analysis on each subgroup will be prepared for review prior to the interviews. Information from the interviews will be used to develop revised GRIM sub-group analyses for consideration in the NOPR.

OOE recommended that the analysis use the minimum number of sub-groups required to fully capture different levels of impact on different sizes and type of manufacturers (OOE, #7).

The Department seeks input from stakeholders on whether the defined sub-groups are appropriate, or whether fewer, or additional, subgroups are needed. Comments are also requested regarding the value in grouping manufacturers into sub-groups, compared to conducting individual GRIM Analysis for each manufacturer. Additional commentary is sought regarding which manufacturers should be asked to participate in the interviews, and, more generally, what a well executed sub-group analysis would entail.

4. Interview Process

a. General

The revised rulemaking process provides for greater public input and for improved analytical approaches, with particular emphasis on earlier and more extensive information gathering from interested parties. The proposed three-phase Manufacturer Impact Analysis process will draw on multiple information sources, including structured interviews with manufacturers and a broad cross-section of interested parties. Interviews may be conducted in any and all phases of the analyses as determined in Phase 1.

The interview process has a key role in the manufacturer impact analyses, since it provides an opportunity for manufacturers to privately express their views on important issues. A key characteristic of the interview process is that it is designed to allow confidential information to be considered in the rulemaking process.

The initial industry characterization will collect information from relevant industry and market publications, industry trade organizations, company financial reports, and product literature. This information will aid in the development of detailed and focused questionnaires, as needed, to perform all phases of the manufacturer impact analyses. It is the intention of the Department that the contents of questionnaires and the list of interview participants be publicly vetted prior to initiating the interview process.

The Phase 3 (sub-group analysis) questionnaire will solicit information on the possible impacts of potential efficiency levels on manufacturing costs, product prices, and sales. Evaluation of the possible impacts on direct employment, capital assets, and industry competitiveness will also draw heavily on the information gathered during the interviews. The questionnaires will solicit both qualitative and quantitative information. Supporting information will be requested whenever applicable.

Interviews will be scheduled well in advance in order to provide every opportunity for key individuals to be available for comment. Although a written response to the questionnaire is acceptable, an interactive interview process is preferred because it helps clarify responses and provides the opportunity for additional issues to be identified.

Interview participants will be requested to identify all confidential information provided in writing or orally. Approximately two weeks following the interview, an interview summary will be provided to give participants the opportunity to confirm the accuracy and protect the confidentiality of collected information. All the information transmitted will be considered, when appropriate, in the Department's decision-making process. However, confidential information will not be made available in the public record.

DOE will collate the completed interview questionnaires and prepare a summary of the major issues and outcomes. The Department will seek comment on the outcome of the interview process.

b. Product Specific

The Department completed a round of preliminary interviews at the start of the

Engineering Analysis that focused on design and cost issues. A second round of interviews will be scheduled soon after publication of the Supplemental ANOPR. The intent will be to develop an accurate representation of the impacts of new standards on each sub-group. As noted previously, the Department intends to examine two sub-groups: high-volume manufacturers and low-volume manufacturers.

H. Competitive Impact Assessment

a. General

EPCA directs the Department to consider any lessening of competition that is likely to result from standards. It directs the Attorney General to gauge the impacts, if any, of any lessening of competition. The Department will make a determined effort to gather and report firm-specific financial information and impacts. The competitive analysis will focus on assessing the impacts to smaller, yet significant, manufacturers. The assessment will be based on manufacturing cost data and on information collected from interviews with manufacturers, consistent with Phase 3 of the manufacturer impact analyses. The Department of Justice (DOJ) has offered to help in drafting questions to be used in the manufacturer interviews. These questions will pertain 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 will focus on gathering information that would help in assessing asymmetrical cost increases to some manufacturers, increased proportion of fixed costs potentially increasing business risks, and potential barriers to market entry (proprietary technologies, etc.).

b. Product Specific

The Department will consult with DOJ prior to conducting the manufacturer interviews and will share the results of those interviews and subsequent analyses with DOJs according to the rulemaking schedule, and as appropriate.

I. Utility Analysis

The Utility Analysis estimates the effects of proposed standards on electric and gas utilities.

1. Proposed Methodology

a. General

To estimate the effects of proposed standards on electric and gas utilities, the Department intends to use EIA's NEMS. NEMS is a large multi-sectoral partial-equilibrium model of the U.S. energy sector that has been developed over several years by EIA primarily to prepare the *AEO*. NEMS produces a widely recognized baseline forecast for the U.S. through 2020, and is available in the public domain. Outputs of the Utility Analysis will parallel results that appear in the latest *AEO*, with some additions. Typical output includes forecasts of sales and price. The entire Utility Analysis will be conducted as a policy deviation from the latest *AEO* using NEMS–BRS, and the assumptions in place in NEMS will serve as the basic set of assumptions that will be applied to the Utility Analysis. For example, the operating characteristics (energy efficiency, emissions rates, etc.) of future electricity generating plants used in the Utility Impact Analysis will be those used in the latest *AEO*. As discussed earlier, NEMS–BRS is a variant of U.S. DOE/EIA's NEMS and is referred to as such for two reasons: (1) The Utility Analysis to be performed entails some minor code modifications and (2) the model will be run under policy deviations that are variations on DOE/EIA assumptions. The name NEMS–BRS refers to the model that will be used for the Utility Analysis (BRS is DOE's Building Research and Standards office).

Forecasting for the electric utility industry is seriously complicated by the implications of industry restructuring, which is only partially reflected in the latest *AEO* (1999). DOE plans to explore the consequences of a wider restructuring pattern through appropriate scenario analysis using NEMS–BRS.

NEMS offers a sophisticated picture of the effect of appliance standards since its scale allows it to measure the interactions between the various energy supply and demand sectors and the economy as a whole. In addition, the scale of NEMS permits analysis of the effects of standards on both the electric and gas utility industries.

b. Product Specific

To analyze the effect of standards, NEMS–BRS will first be run exactly as it would be to produce an *AEO* forecast, then a second run will be conducted with residential energy usage reduced by the amount of energy (gas, oil, and electricity) saved due to appliance standards for central air conditioners and heat pumps. The energy savings input will be obtained from the NES spreadsheet (section II.E.1). Outputs available are the same as those in the original NEMS model, including residential energy prices, generation, and installed capacity (and, in the case of electricity, which primary fuel is used for generation). Other than the difference in energy consumption due to central air conditioner and heat pump standards, input assumptions into NEMS–BRS will follow those used to produce the 1999 *AEO*.

Since the *AEO* 1999 version of NEMS–BRS forecasts only to the year 2020, a method for extrapolating price data to 2030 is required. The method adopted will be the EIA approach to forecasting fuel prices for the Federal Energy Management Programs (FEMP). These are the prices used by FEMP to estimate LCCs of Federal equipment procurement. For petroleum products, the average growth rate for the world oil price over the years 2010 to 2020 is used in combination with the refinery and distribution markups for the year 2020 to determine regional price forecasts. Similarly, natural gas prices are derived from an average growth rate along with regional price margins for the year 2020. Electricity prices are held constant at 2020 levels on the assumption that the transition to a restructured utility industry will have been completed.

In principle, any of the forecasts that appear in the *1999 AEO* could be estimated by NEMS–BRS to take into account the effects of a particular level of central air conditioner and heat pump standards. The Department intends to report the major results on residential sales of fuels, prices of fuels, and generating sources displaced by energy savings. As might be expected, as the total energy use of America is much larger than that possible due to the savings from central air conditioners and heat pumps, there is little expected difference in the forecasted price of energy.

EEI stated that the Utility Analysis should incorporate the impact of any new standard on the equipment's Energy Efficiency Ratio (EER) rating in order to establish the impact on peak loads and power plant operation. The analysis should also be market based, and take into account that several merchant plants are coming on-line and that customers, rather than utility dispatchers, will dictate how power plants are utilized to meet air conditioning loads. (EEI, #2) Since it incorporates representative load shapes for central air conditioners and heat pumps, NEMS–BRS has the capability to determine both the impacts on power plant operation and peak loads that result from central air conditioner and heat pump energy savings. Thus, the type of power plant that will go off-line and the resulting reduction in peak loads can and will be determined.

J. Environmental Analysis

An Environmental Assessment is required pursuant to the National Environmental Policy Act of 1969 (NEPA) (42 U.S.C. 4321 *et seq.*), regulations of the Council on Environmental Quality (49 CFR parts 1500–1508), the Department regulations for compliance with NEPA (10 CFR part 1021), and the Secretarial Policy on the National Environmental Policy Act (June 1994). The Department will present a discussion of the Draft Environmental Assessment as part of the NOPR. The Department will present the Draft Environmental Assessment in the Technical Support Document for the NOPR. The NOPR will provide an opportunity for comments prior to the final rule.

The Environmental Analysis will track three types of energy-related airborne emissions: sulfur dioxide (SO_2), nitrogen oxides (NO_x) and carbon dioxide (CO_2). The first two have direct consequences for human health, and are major causes of acid precipitation, which can affect humans by reducing the productivity of farms, forests and fisheries, decreasing recreational opportunities and degrading susceptible buildings and monuments. NO_x is also a precursor gas to urban smog and is particularly detrimental to air quality during hot, still weather. CO_2 emissions are believed to contribute to raising the average global temperature via the ''greenhouse effect.'' The long-term consequences of higher temperatures may include perturbed air and ocean currents, perturbed precipitation patterns, changes in the gaseous equilibrium between the atmosphere and the biosphere, and the melting of some of the ice now covering polar lands and oceans, causing a rise in sea level. The source of emissions covered in this analysis is fossil fuel-fired electricity generation.

1. Proposed Methodology

a. General

To perform the Environmental Analysis, the Department intends to use NEMS–BRS, which it also uses for the Utility Impact Analysis described in the previous section. Outputs of the Environmental Analysis will parallel results that appear in the latest *AEO*, with some additions. The Department will conduct entire Environmental Analysis as a policy deviation from the latest *AEO* using NEMS–BRS, and the assumptions in place in NEMS will serve as the basic set of assumptions that will be applied to the Environmental Analysis.

Carbon emissions (which are a physically equivalent indicator of actual emissions of carbon dioxide) are tracked in NEMS–BRS by a detailed carbon module with broad coverage of all sectors and inclusion of interactive effects. NEMS–BRS also includes a module for SO_2 allowance trading and delivers a forecast of SO_2 allowance prices. Accurate simulation of SO_2 trading, however, tends to imply that physical emissions effects will be zero. This fact has caused considerable confusion in the past, and, in prior appliance standards analyses, a simple figure for emission reductions has been reported, with the caveat that emissions trading implies that this reduction will unlikely be realized. On the other hand, there is an SO_2 benefit from conservation in the form of a lower allowance price. If the reduction in allowance price is large enough to be calculable by NEMS–BRS, the Department will report this value.

The results for the Environmental Analysis can be in the form of a complete NEMS–BRS run. In general, NEMS–BRS outputs become the tables of an *AEO*, and these should provide a good idea of the range of results available. Outputs from a NEMS–BRS run include SO_2, NO_X and CO_2 emissions from the power sector and a trading price for SO_2 allowances. The only form of carbon tracked by NEMS–BRS is CO_2, so the carbon discussed in the analysis is only in the form of CO_2 but is reported as elemental carbon to remain consistent with the *1999 AEO*. The conversion factor from carbon to CO_2 is approximately 3.7.

b. Product Specific

The version of NEMS used for appliance standards analysis is called NEMS–BRS, and is based on the *1999 AEO* version with minor modifications. NEMS–BRS is run exactly the same as the original NEMS, except that residential energy usage is reduced by the amount of energy (gas, oil, and electricity) saved due to central air conditioner and heat pump standards. The amount of energy savings is obtained from the NES spreadsheet (Section 8.2). The output of the Environmental Analysis is forecasted physical emissions. The net benefits of a standard will be the difference between emissions estimated by the *AEO* 1999 version of NEMS–BRS and those estimated with a standard in place.

Energy use for central air conditioner and heat pump efficiency levels will be the same as those in the NES spreadsheet. Other input assumptions into NEMS–BRS will follow those used to produce *AEO* 1999. In principle, any of the forecasts that appear in *AEO* 1999 could be estimated by NEMS–BRS to take into account the effects of a particular central air conditioner and heat pump efficiency standard level, but, in the standard reporting, the Department intends to report emissions of SO_2, NO_X and CO_2.

The time horizon of NEMS–BRS is 2020. The Department will extrapolate beyond 2020 using a simple formula (according to the method set out in the Preliminary TSD) to extend the forecast to 2030. The Department will generate alternative price forecasts corresponding to the side cases found in *AEO* 1999 for use by NES and will explore alternatives in a similar fashion with NEMS–BRS runs.

EEI stated the environmental impact results generated from NEMS will be less accurate than they could be, since consumers may switch electricity suppliers and since the impacts from other emissions, such as carbon monoxide and precursor organic compounds, are not being analyzed.(EEI, #2) EMPA also stated that NEMS does not accurately account for recent changes in the electric utility industry. (EMPA, #3) Although NEMS might have some short comings, the Department believes that NEMS–BRS is the most appropriate and accurate model to estimate environmental impacts. Although the Department is comfortable with the use of NEMS–BRS for establishing environmental impacts, interested parties are welcome to present any other models or data that could verify or refute the NEMS estimates.

K. Regulatory Impact Analysis

DOE will be preparing a draft Regulatory Analysis pursuant to E.O. 12866, ''Regulatory Planning and Review,'' which will be subject to review under the Executive Order by the Office of Information and Regulatory Affairs (OIRA) 58 FR 51735 (October 4, 1993).

As part of the Regulatory Analysis, the Department will identify and seek to mitigate the overlapping effects on manufacturers of new or revised DOE standards and other regulatory actions affecting the same products. Through manufacturer interviews and literature searches, the Department will compile information on burdens from existing and impending regulations affecting central air conditioners (e.g. HCFC phase out) and other products (e.g. room air conditioners). The Department also seeks input from stakeholders regarding other regulations that should be considered.

III. Proposed Standards Scenarios

Upon reviewing the preliminary LCC and NES results, the Department observes that the efficiency levels analyzed; (generally a 10 to 70 percent improvement over the existing standard), produced a range of impacts at the National level. For example, the NES impacts show a range from 0.81 to 14.11 quads of energy saved over the 2006 to 2030 period. As expected, the higher the efficiency level, the greater the savings.

The national Net Present Value (NPV), which is the discounted sum over future years of the operating cost savings in energy less the increase in first cost of more efficient units, also showed a range of impacts. A positive NPV is a net benefit to the nation. The NPVs based on reverse engineering costs show positive benefits to the Nation for all efficiency levels less than 13 SEER (with the exception of the 12 SEER efficiency level for split system air conditioners), while NPVs based on industry-provided manufacturer costs show negative benefits to the nation for all efficiency levels.

At the consumer level, the LCC and payback analyses results also depend on manufacturer costs. For example, with reverse engineering costs, minimum LCC occurs at 12 SEER for all product classes, and with industry-provided costs, minimum LCC occurs at 12 SEER for heat pumps (both split system and packaged), but there is no minimum LCC for air conditioners. Payback analyses for SEER 12 equipment also show a range of payback times varying from 3 to 15 years, depending on the product class and the manufacturer costs.

The maximum technologically feasible efficiency levels for these products (approximately 20 SEER in 2006) were not explicitly analyzed in this Supplemental ANOPR because the Department assumed that the products could not be economically justified. While the split-system air conditioner with the highest efficiency in the market in 1998 was rated at SEER 18, the most efficient product analyzed in this Supplementary ANOPR was SEER 17. At this efficiency level, all the products had greater LCCs than the baseline and had payback periods that exceeded the mean product lifetime. The Department assumed that products with efficiencies greater than SEER 17 would have greater incremental costs than incremental savings, and that, consequently, efficiency levels greater than SEER 17 could not be economically justified. This assumption will be reexamined prior to issuance of the NOPR, where products at the maximum technologically feasible level will be analyzed.

Based on the analyses performed, the Department observes that, depending on product class, efficiency levels ranging from 11 to 13 SEER would appear to result in the greatest economic benefit to the Nation. The Process Rule requires the Department to specify in the ANOPR candidate standards levels, but not to propose a particular standard. Because the preliminary LCC and NES results show economic benefits to both consumers and to the Nation in the SEER 11 to 13 efficiency range, the Department intends to further consider and conduct analyses for the following candidate standards levels, for each product class, prior to issuance of the NOPR:

- SEER 11
- SEER 12
- SEER 13

In addition, the Department intends to conduct Engineering and LCC analyses specifically for the Maximum Technologically Feasible (approximately SEER 20) level for each product class prior to issuance of the NOPR.

Split System Central Air Conditioners: The minimum mean LCC for split system air conditioners occurs at either 11 or 12 SEER, based on the industry cost data or the reverse engineering manufacturing cost data, respectively. Although the minimum mean LCC occurs at efficiency levels greater than the baseline (10 SEER) in both of the these cases, the percent of the population with LCCs lower than the baseline is less than 50% (39% at 11 SEER, based on industry data, and 45% at 12 SEER, based on reverse engineering data). The median payback periods corresponding to the industry data and reverse engineering LCC minimums, 13 and 11 years, respectively, are both less than the 18.4 year average product lifetime. However, mean payback periods exceed the average product lifetime.

Split System Heat Pumps: The minimum mean LCC for split system heat pumps occurs at 12 SEER for both the industry cost data and the reverse engineering manufacturing cost data, although based on the reverse engineering cost data, the mean LCC corresponding to 13 SEER is also less than that for the baseline. The percent of the split heat pump population at 12 SEER with LCCs lower than the baseline is well above 50% based on both the industry data and reverse engineering cost data (63% based on industry data and 90% based on reverse engineering). The median payback periods corresponding to the industry data and reverse engineering LCC minimums, 8 and 3 years, respectively, are both less than the average 18.4 year product lifetime.

Single Package Air Conditioners: The minimum mean LCC for single package air conditioners occurs at either 10 or 12 SEER, based on the industry cost data or the reverse engineering manufacturing cost data, respectively. The percent of the population at 12 SEER with LCCs lower than the baseline varies significantly depending on which cost data are used; the industry cost data results in a percentage of 26% while the reverse engineering cost data results in a percentage of 58%. The median payback periods corresponding to the industry data at 11 SEER efficiency level and the reverse engineering 12 SEER efficiency level are 20 and 8 years, respectively.

Single Package Heat Pumps: The minimum mean LCC for single package heat pumps occurs at 12 SEER for both the industry cost data and the reverse engineering manufacturing cost data. The percent of the single package heat pump population at 12 SEER with LCCs lower than the baseline is above 50% (58% and 80%, based on industry data and reverse engineering data, respectively). The median payback periods corresponding to the industry data and reverse engineering LCC minimums, 9 and 5 years, respectively, are less than the mean lifetime of the product.

The above observations are based on preliminary LCC and NES results, which will be updated and revised in the NOPR and final rule analyses. The LCC and NES results are considered preliminary because they do not include any results from the manufacturer impact and consumer subgroup analyses, or contain information from a consumer survey. The Department seeks comments on whether standards that meet alternative scenarios would provide energy savings to the Nation comparable to the savings that would be obtained by the highest standards that are technologically feasible and economically justified effective in 2006. Standards that meet the following alternative scenarios, for example, might be presented to the Department for consideration:

- A moderate increase in the efficiency level at an earlier effective date, for example, an effective date three years after the publication of the Final Rule.
- A stringent increase in efficiency level at a later effective date, for

example, an effective date in 2010 coinciding with the HCFC–22 phase out.

• A two-phase approach combining the two scenarios, for example, a lower efficiency level for some product classes effective at an earlier date and a higher efficiency level effective at a later date.

The Department seeks comments on standards under various scenarios, including the candidate standards, for consideration in preparing the analysis on which the Department will base the proposed rule.

IV. Public Comment Procedures

A. Participation in Rulemaking

The Department encourages the maximum level of public participation possible in this rulemaking. Individual consumers, representatives of consumer groups, manufacturers, associations, States or other governmental entities, utilities, retailers, distributors, manufacturers, and others are urged to submit written statements on the analysis presented here.

The Department has established a period of 75 days following publication of this notice for persons to comment. All public comments received will be available for review in the Department's Freedom of Information Reading Room. In addition, the following data is available in the Department's Freedom of Information Reading Room:

- Copies of the Preliminary TSD
- Transcripts of the Central Air Conditioning policy Workshop held on June 30, 1998
- Copies of the public comments received by the Department thus far
- Previous **Federal Register** notices relating to this central air conditioner and heat pump rulemaking

A public hearing will be held on December 9, 1999, (9 a.m.—5 p.m.), at the U.S. Department of Energy, Forrestal Building, 1000 Independence Avenue SW, Room 1E–245, Washington, DC 20585. More detailed information about this hearing will be on the Office of Codes and Standards web site beginning in November. The web site address is as follows: http://www.eren.doe.gov/buildings/codes standards/index.htm.

B. Written Comment Procedures

Interested persons are invited to participate in this proceeding by submitting written data, views, or arguments with respect to the subjects set forth in this notice. Comments will not be accepted by fax or e-mail. Instructions for submitting written comments are set forth at the beginning of this notice and in this section.

Comments should be labeled both on the envelope and on the documents, ''Central Air Conditioners and Heat Pumps Rulemaking (Docket No. EE-RM–94–403),'' and must be received by the date specified at the beginning of this document. The Department requests that ten copies of your comments be submitted. Additionally, the Department would appreciate an electronic copy of the comments to the extent possible. The Department is currently using WordPerfect™ 8. All comments and other relevant information received by the date specified at the beginning of this notice will be considered by the Department in the proposed rule.

All written comments received on this supplemental Advance Notice of Proposed Rulemaking will be available for public inspection at the Freedom of Information Reading Room, as provided at the beginning of this notice.

Pursuant to the provisions of 10 CFR 1004.11, any person submitting information or data that is believed 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 will make its own determination with regard to the confidential status of the information or data and treat it according to its determination.

Factors of interest to the Department, when evaluating requests to treat information as confidential, include: (1) A description of the item; (2) an indication as to whether and why such items of information have been treated by the submitting party as confidential, and whether and why such items are customarily treated as confidential, and whether and why such items are customarily treated as confidential within the industry; (3) whether the information is generally known or available from other sources; (4) whether the information has previously been available to others without obligation concerning its confidentiality; (5) an explanation of the competitive injury to the submitting person that 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) whether disclosure of the information would be in the public interest.

C. Issues for Public Comment

The Department is interested in receiving comments and data to improve its preliminary analysis. In particular, the Department is interested in responses to the following questions and/or concerns that were addressed in this notice.

1. Differences between the industry and the reverse engineering cost data:

• Use of the industry and the reverse engineering cost data yield significantly different LCC, payback period, NES, and NPV results. Efforts preceding the publication of this Supplemental ANOPR between the Department and the industry have yet to reveal why differences still persist between the two sets of cost data. Continued efforts and suggestions are needed to resolve the differences between the two cost data sets. These differences are discussed in the Process Improvement section (I B.3.).

2. The incorporation of emerging technologies into the Engineering Analysis:

• The Department has conducted a preliminary analysis of how emerging technologies may impact the manufacturing costs of achieving higher efficiency levels. But due to the uncertainty associated with the future development of these technologies, in particular, microchannel heat exchangers, advanced compressors, and variable speed motor controls, the costs currently projected for their incorporation into air conditioning and heat pump equipment may change significantly.

3. The assessment of the impacts on steady-state efficiency, i.e. EER, due to increases in the SEER:

• Comments submitted by the EEI and the ACEEE call for assessments of how the Energy Efficiency Ratio (EER) of air conditioning and heat pump equipment may be impacted by an increase in the SEER. In particular, they are concerned that a higher efficiency standard based on SEER may lead to a decrease in steady-state efficiency during peak demand because of the prevalence of modulating systems at the higher SEER levels. Up to efficiency levels of 12 SEER, the rate of EER increase is directly proportional to the increase in SEER as manufacturers typically rely on single-speed technology to attain the SEER increase. But as efficiency levels move beyond 12 SEER, manufacturers use an array of technologies that have significantly different impacts on EER. How should the Department quantify the relationship of EER to the higher SEER values?

4. For heat pump systems, the relationship between SEER and HSPF:

• Based on heat pumps in the marketplace, a range of HSPF values are possible for any particular SEER. But recognizing that the HSPF of heat pump equipment generally increases with

SEER, the current analysis assumes a simple relationship between the two efficiency descriptors for purposes of setting an HSPF standard in addition to a SEER standard for heat pumps. Should the Department continue with this simple approach or should another procedure be developed to assess the impact of SEER on HSPF?

5. Additional product classes based on system capacity:

• The current analyses are based on manufacturing cost data developed for nominal 3-ton capacity systems. Although product shipments are predominantly at nominal capacities of 3-tons, the cost of achieving higher efficiency for systems with higher and lower capacities may be different. If data submitted in response to this Supplemental ANOPR reveals significantly different manufacturing cost increases based on system capacity, the Department will analyze whether this results in justifiably lower or higher efficiency levels for equipment of differing capacity.

6. Niche product classes:

• Several manufacturers have asked the Department to establish new classes to protect the viability of certain niche products under higher efficiency standards. These products (ductless split systems, high-velocity/small duct systems, vertical packaged/wall mounted systems, and through-the-wall condensing units) serve niche markets and probably account for less than three percent of the residential unitary market. As such, the efficiency standard established for these products will have little effect on NES and consumer LCC. The Department seeks comments as to whether these products provide a unique utility that cannot be met by other products. One important question is whether the constraints imposed by higher standards would eliminate these products from the marketplace. For this reason the Department is also interested in recommendations as to how to define these new product classes so that these products would continue to be available to satisfy the unique needs for which they are intended.

7. The impact of alternative refrigerants for HCFC–22:

• The current analysis assumes that the phase-out date for HCFC–22 is far enough in the future that it will not affect a manufacturer's ability to meet any new efficiency standards, whether using HCFC–22 before the phase-out, or using alternative refrigerants before and after the phase-out. Through manufacturer interviews and literature searches, the Department plans to compile information on burdens from existing and impending regulations affecting central air conditioners (e.g. HCFC phase out). But should the Department more explicitly account for the impact of the HCFC phase out in the Engineering Analysis? Any analysis in this area will require assessment of the impact on manufacturer cost due to the use of the alternative refrigerant.

8. Data on retail mark-up assumptions:

• Retail mark-up assumptions are based upon the following distribution chain: manufacturer-to-distributor/wholesaler-to-contractor/dealer. Although this is not the only type of distribution chain currently in existence for central air conditioning and heat pump equipment, it is assumed that the mark-ups reflected by this chain of distribution will reflect the mark-ups resulting from other methods of distribution (*e.g.,* manufacturer directly to dealer). At present the Department does not intend to change the retail mark-up assumptions but will continue to research data sources and seek comment on this issue.

9. Information relating to the determination of price and operating cost elasticities in conducting shipment forecasts:

• In order to determine the effect of an increase in the purchase price and operating cost on shipments, it would be useful to know the elasticities of central air conditioner and heat pump prices and operating costs. Due to the lack of data in this area specific to central air conditioners and heat pumps, the Department is currently using elasticities developed from analyses conducted over twenty years ago. With regard to purchase price, in making estimates of these effects, the Department needs to estimate how price changes resulting from revised energy efficiency standards for central air conditioners and heat pumps will affect the behavior of consumers in their purchasing decisions.

10. Data on the possible adverse affects of standards on identifiable groups of consumers that experience below-average utility or usage rates:

• The consumer analysis can evaluate impacts on any identifiable groups, such as consumers of different income levels, who may be disproportionately affected by any national energy efficiency standard level.

11. Information on what non-regulatory alternatives to standards need to be reviewed:

• Under the Process Rule policies, the Department is committed to continually explore non-regulatory alternatives to standards. The table following presents what is being proposed for consideration in this rulemaking. The Department is seeking comments on this approach. This approach is further discussed in the Preliminary TSD.

Alternatives To Be Considered

—No new regulatory action
—Consumer tax credits
—Manufacturer tax credits
—Performance standards
—Rebates
—Voluntary energy efficiency targets
—Early replacement
—Mass government purchases

12. Comments on the candidate standard levels and the alternative standard scenarios.

• The Department has identified candidate standards levels of 11 SEER, 12 SEER and 13 SEER for all product classes. The Department has also provided examples of several alternative scenarios which could have different effective dates and different standards levels but which could provide comparable energy savings.

V. Review Under Executive Order 12866 and Other Provisions

DOE provided to the Office of Information and Regulatory Affairs (OIRA) in the Office of Management and Budget a copy of this document for comment. At the proposal stage for this rulemaking, DOE and OIRA will determine whether this rulemaking is a significant regulatory action under Executive Order 12866, Regulatory Planning and Review. 58 FR 51735 (October 4, 1993). Were DOE to propose amendments to the energy conservation standards for central air conditioners and heat pumps, the rulemaking could constitute an economically significant regulatory action and DOE would prepare and submit to OIRA for review the assessment of costs and benefits required by Section 6(a)(3) of Executive Order 12866. Other procedural and analysis requirements in other Executive Orders and statutes also may apply to such future rulemaking action, including the requirements of the regulatory Flexibility Act, 5 U.S. C. 601 *et seq.*; the Paperwork Reduction Act, 44 U.S.C. 3501 *et seq.*; and the Unfunded Mandates Act of 1995, Pub. L. 104–4; and the National Environmental Policy Act of 1969, 42 U.S. C. 4321 *et seq.*

Today's action and any other documents submitted to OIRA for review have been made 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, Room 1E–190, Washington, DC 20585 between the hours of 9 and 4, Monday through Friday, telephone (202) 586–3142.

Issued in Washington, DC, on November 8, 1999.

Dan W. Reicher,

Assistant Secretary, Energy Efficiency and Renewable Energy.

[FR Doc. 99–30480 Filed 11–23–99; 8:45 am]

BILLING CODE 6450–01–P