Energy Conservation Standards Rulemaking
Peer Review Report – Supporting Documentation

Submitted Pursuant to the Office of Management and Budget's "Final Information Quality Bulletin for Peer Review"

U.S. Department of Energy
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PROJECT ABSTRACTS

PROJECT ABSTRACTS FOR
Appliance Standard Analyses

Background of Appliance Standards:

The appliance standards program was initiated in 1979. From 1979 to 2001, the analysis provided information in support of three legislated amendments to the Energy Policy and Conservation Act: National Appliance Energy Conservation Act (1987), Amendment to NAECA (1988), Energy Policy Act (1992). Subsequently, the analysis directly supported 17 updates of the initial federal energy efficiency regulations.

Section 6313(a)(6)(A) of 42 U.S.C. requires the DOE to set forth energy conservation standards that are technologically feasible and economically justified and would result in significant energy conservation. The following elements of the appliances standards analysis are designed to meet the legislative requirements:

- Market and technology assessment to characterize the relevant equipment markets and existing technology options, including prototype designs.
- Screening analysis to review each technology option and determine if it is practicable to manufacture, install, and service, would adversely affect equipment utility or equipment availability, or would have adverse impacts on health and safety.
- Engineering analysis to develop cost/efficiency relationships that show the manufacturer's cost of achieving increased efficiency.
- Life-cycle cost (LCC) and payback period (PBP) analysis to calculate, at the customer level, the discounted savings in operating costs (less maintenance and repair costs) throughout the estimated average life of the covered equipment, compared to any increase in the installed cost for the equipment likely to result directly from the imposition of the standard.
- National impact analysis to assess the aggregate impacts at the national level of the net present value (NPV) of total consumer life-cycle cost and national annual and cumulative energy savings.
- Sub-group analysis to evaluate variations in LCC among applications (e.g., energy prices, usage behavior, and installation costs) that might cause a standard to impact particular consumer sub-populations differently than the overall population.
- Manufacturer impact analysis to estimate the financial impact of standards on manufacturers and to calculate impacts on competition, employment, and manufacturing capacity.
- Utility impact analysis to estimate the effects of proposed standards on electric and/or gas utilities.
- Environmental assessment to provide estimates of changes in emissions (e.g., nitrogen oxides and carbon dioxide).
- Employment impact analysis to assess the aggregate impacts on national employment.
- Regulatory impact analysis to present major alternatives to proposed standards that could achieve substantially the same regulatory goal at a lower cost.

Status of Appliance Standards:

For standards in place by 2001 for 13 residential product types, the cumulative retrospective impacts and the projected cumulative impacts through 2025 include energy savings of 44 Quads (primary), net present value of consumer benefit of $111 billion ($202 billion operating cost savings less $91 billion increased equipment prices), and reduced emissions of 4.4 million tons of NO_x and 700 millions tons C of carbon dioxide. There are additional (smaller) savings for commercial products.

In FY2004, analysis for three product types (commercial unitary air conditioners and heat pumps, distribution transformers, and residential furnaces and boilers) was completed, documented as Technical Support Documents, and published as part of Advance Notices of Proposed Rulemakings on July 29, 2004.

In FY2005, analysts reviewed stakeholder comments and prepared an analysis plan for the next phase for each of these three product types. Analysis is now in progress for Notices of Proposed Rulemakings. In addition, analysts have provided briefing materials for DOE's consideration in making a determination about whether to analyze standards for two other product types (high intensity discharge lamps and small electric motors). In preparation for an annual priority setting exercise, analysis has begun on potential energy savings for refrigerator-freezers and other products.

Appliance Standards Analyses Subjected to Peer Review:

The following five abstracts (Screening Analysis/Engineering Analysis; Markups for Appliance Price Determination/Life-Cycle Cost & Payback Period Analysis/Life-Cycle Cost Consumer Sub-group Analysis; Shipments Analysis/National Impacts Analysis; Manufacturer Impact Analysis; and Utility Impact Analysis/Environmental Assessment/Employment Impact Analysis/Regulatory Impact Analysis) will be the subject of this peer review. This is only a brief overview of these projects and will be followed up by a more detailed project description and other informational material later upon final selection the peer review panelists.

I. PROJECT ABSTRACT

1. Project Title: Appliance Standards Analysis — Screening Analysis; Engineering Analysis

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3. Project Schedule:

1. Initiation Date: Original project started in 1979, composed of product-specific elements. Current rulemakings started in 2001 for three product types.
2. Expected Completion Date: Current rulemakings will be completed in FY2007.

4. Statement of Problem:

In the screening analysis, the Department develops an initial list of efficiency enhancement design options. This list of options is reviewed in consultation with interested parties, 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. Those efficiency enhancement options that fail one or more of these screening criteria are not considered further in the Department's analysis. Those design options that pass the screening criteria are used in the engineering analysis.

The engineering analysis develops cost-efficiency relationships, estimating manufacturer costs of achieving increased efficiency levels. Manufacturing costs are used as the basis for determining retail prices in the life-cycle cost analysis, and are needed for the manufacturer impact analysis. The engineering analysis also determines the maximum technologically feasible efficiency level.

The Energy Policy Conservation Act (EPCA) provides seven factors to be considered by the Secretary of Energy when determining whether an appliance efficiency standard [energy conservation standard] is justified. (42 U.S.C. 6313(a)(6)(B)(i)). The screening analysis and engineering analysis evaluate whether there is any impact on utility or performance, one of these factors. Furthermore, the cost-efficiency relationship developed in the engineering analysis is a critical input to the LCC analysis which addresses the economic impact on consumers and manufacturers and determines lifetime operating cost savings, two more of these factors.

5. Project Objectives: The objectives of the effort during FY-2005 are to: (1) provide any updates or improvements to the screening analysis for high priority products (i.e., commercial unitary air conditioners, distribution transformer, and residential furnaces and boilers), (2) continue conducting the engineering analyses for the high priority products; and (3) provide complete documentation of each analysis.

6. Technical Approach:

- Screening Analysis: The Department develops, with input from interested parties, a list of design options for further consideration. The Department eliminates from further consideration a design option that: Is not technologically feasible; is not practicable to manufacture, install and service; has significant adverse impact on the utility of the product to consumers; or adversely affects health or safety. Consistent with Natural Resources Defense Council v. Herrington, 768 F.2d 1355 (D.C. Cir. 1985), the Department evaluates design options for technological feasibility on the basis of whether the options are in use by industry or research has progressed to the development of a prototype. However, consideration of practicability to manufacture, impacts on consumer utility and health and safety effects at this stage is designed to ensure that commercially impractical designs, even if technologically feasible, are screened out on the basis of other statutory criteria early in the process. This early screening approach reduces uncertainty as to the direction of standards development. The screening process includes consultations with interested parties and independent technical experts who can assist with identifying the key issues and design options or efficiency levels. The screening analysis also discusses the criteria for eliminating certain design options or efficiency levels from further consideration. By comparing the design options or efficiency levels against these criteria, the Department eliminates from further analysis those options or efficiency levels that are not sufficiently developed or have characteristics that make them technologically unsuitable for consideration in the rulemaking. The Department will consider in the analyses, wherever feasible, data, information and analyses received from stakeholders.

- Engineering Analysis: In consultation with outside experts, the Department selects the specific engineering analysis tools to be used in the evaluation. There are three general approaches for developing cost-efficiency schedules: the "efficiency level approach," the "design option approach," and the "cost assessment approach." The critical inputs to the engineering analysis are data from manufacturers and/or experts in designing and costing transformers. This includes the cost-efficiency information available through retail prices and their existing efficiencies. However, information is also required to estimate, for some products, cost-efficiency tradeoffs that may not be available from current market information. This type of information may be developed by manufacturers, from simulation models and/or by design experts.

7. Overall Budget: N/A.

8. Status/Interim Results: In September, 1995, the Department announced a formal effort to consider further improvements to the process used to develop appliance efficiency standards. The Department called on energy efficiency groups, manufacturers, trade associations, state agencies, utilities, and other interested parties to provide input to this effort. As a result of this combined effort, the Department published *Procedures, Interpretations and Policies for Consideration of New or Revised Energy Conservation Standards for Consumer Products* (the "Process Rule"), 10 CFR 430, Subpart C, Appendix A. During the consultations some manufacturers expressed concern that the Department devoted too much attention to consideration of design options that: were not practical to mass manufacture, install or service; had substantial impacts on consumer utility; or raised significant safety concerns. The screening analysis was designed to address these concerns. Since publication of the process rule, three rulemaking were completed under its policies and procedures:

- *Clothes Washers*: Effective date = 2004
- *Residential Water Heaters*: Effective date = 2007
- *Residential Central Air Conditioners and Heat Pumps*: Effective date = 2006

II. PROJECT ABSTRACT

1. Project Title: Appliance Standards Analysis — Markups for Appliance Price Determination; Life-Cycle Cost and Payback Period Analysis; Life-Cycle Cost Consumer Sub-group Analysis

2. Principal investigator: James E. McMahon, Head, Energy Analysis Department, Lawrence Berkeley National Laboratory, 1 Cyclotron Rd 90R4000, Berkeley, CA 94720-8136. Phone: 510 486 6049. Fax: 510 486 6996. Email: JEMcMahon@LBL.gov URL: http://eetd.lbl.gov\EA\EA_org.html

3. Project Schedule:

1. Initiation Date: Original project started in 1979, composed of product-specific elements. Current rulemakings started in 2001 for three product types.
2. Expected Completion Date: Current rulemakings will be completed in FY2007.

4. Statement of Problem: To calculate the consumer life-cycle cost (LCC) of appliances meeting potential new efficiency standards for both the general population of appliance consumers as well as particular sub-groups that that may not be able to afford significant increases in appliance retail price. One of the primary components of the consumer LCC is the retail purchase price. Markups are used to transform the manufacturer price of an appliance into a consumer retail purchase price.

The Energy Policy Conservation Act (EPCA) provides seven factors to be evaluated in determining whether an appliance efficiency standard [energy conservation standard] is economically justified. (42 U.S.C. 6313(a)(6)(B)(i)) The consumer life-cycle cost (LCC) is one of the seven factors. Generally, if the consumer LCC of a potential new appliance efficiency standard is lower than the LCC of the baseline efficiency level (typically the existing minimum efficiency standard), economic justification is demonstrated on an LCC-basis.

5. Project Objectives: The objectives of the effort during FY-2005 are to: (1) continue conducting the markup, LCC, and LCC consumer sub-group analyses for high priority products (i.e., commercial unitary air conditioners, distribution transformer, and residential furnaces and boilers); and (2) provide complete documentation of each analysis.

6. Technical Approach:

- Markups for Appliance Price Determination: In order to carry out the LCC calculations, the price to the consumer of baseline appliances, and the price of more-efficient appliances that consumers would purchase under a new efficiency standard must be determined. The consumer price is determined by applying a multiplier called a "markup" to the manufacturer price. Markups are based on a combination of firm balance sheet data and U.S Census Bureau data for companies that are involved in the distribution and installation of the appliance. Markups are differentiated between a baseline markup and an incremental markup. Baseline markups are defined as coefficients that relate the manufacturer's price of baseline equipment to the sales price of such equipment. Incremental markups are coefficients that relate changes in the manufacturer's price of baseline equipment to changes in the sales price.

- LCC and Payback Period: The consumer LCC is the sum of the purchase price, including the installation, and the operating expense — including operating energy, maintenance, and repair expenditures — discounted over the lifetime of the appliance. The payback period (PBP) is calculated by dividing the change in the total installed cost by the change in operating expenses. However, unlike the LCC, the PBP considers only the first year's operating expenses. The LCC and PBP analysis generates results using a simulation based on Monte Carlo statistical analysis 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 PBP results. A distinct advantage of this type of approach is that the percentage of consumers achieving LCC savings or attaining certain PBP values due to an increased efficiency standard, in addition to the average LCC savings or average PBP for that standard, can be determined. Because the analysis is conducted in this way, uncertainties associated with the various input variables are expressed as probability distributions.

- LCC Consumer Sub-group: The LCC consumer sub-group analysis evaluates variations in appliance characteristics (e.g., energy prices, equipment use behavior, installation costs) that might cause a standard to impact particular consumer sub-populations differently than the overall population. Thus, the sub-group analysis is conducted in the same manner as the LCC analysis but on a smaller population of consumers.

7. Overall Budget: N/A

8. Status/Interim Results: In FY2004, analysis for three product types (commercial unitary air conditioners and heat pumps, distribution transformers, and residential furnaces and boilers) was completed, documented as Technical Support Documents, and published as part of Advance Notices of Proposed Rulemakings. In FY2005, analysts reviewed stakeholder comments and prepared an analysis plan for the next phase. Analysis is now in progress for Notices of Proposed Rulemakings.

III. PROJECT ABSTRACT

1. Project Title: Appliance Standards Analysis — Shipments Analysis; National Impacts Analysis

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3. Project Schedule:

1. Initiation Date: Original project started in 1979, composed of product-specific elements. Current rulemakings started in 2001 for three product types.
2. Expected Completion Date: Current rulemakings will be completed in FY2007.

4. Statement of Problem: To calculate the national impacts of appliances meeting potential new efficiency standards. Two metrics are used to assess national impacts: (1) national energy savings (NES) and (2) consumer net present value (NPV) (i.e., national consumer life-cycle cost savings). Integral to calculating national impacts is forecasting appliance shipments and estimating the impact to appliance shipments due to the amended efficiency standards.

The Energy Policy Conservation Act (EPCA) provides seven factors to be evaluated in determining whether an appliance efficiency standard [energy conservation standard] is economically justified. (42 U.S.C. 6313(a)(6)(B)(i)) EPCA requires DOE, in determining the economic justification of such a standard, to consider the total projected national energy savings that are expected to result directly from the standard. (42. U.S.C. 6313(a)(6)(B)(i)(III)). Generally, if the NES due to a potential new appliance efficiency standard is significant, economic justification is demonstrated on an NES-basis.

5. Project Objectives: The objectives of the effort during FY-2005 are to: (1) continue conducting the shipments and national impacts analyses for high priority products (i.e., commercial unitary air conditioners, distribution transformer, and residential furnaces and boilers); and (2) provide complete documentation of each analysis.

6. Technical Approach:

- Shipments: An accounting model is used to prepare shipment forecasts for the base case (i.e., the case without amended appliance efficiency standards) and the various standard cases considered. The accounting model is organized into three classes of elements: stocks, events, and decisions. "Stocks" are the inventory of installed equipment, and the accounting model divides stocks of appliances into ownership categories, and assigns units to age categories. "Events" are things that happen to stocks independent of economic conditions, i.e., breakdowns requiring repair or replacement. "Decisions" are consumer purchase decisions that are reactions to market conditions, e.g., whether to repair or replace equipment, or to purchase an appliance for a building that does not have one. The accounting model characterizes consumer purchase decisions by market segments. The model uses decision trees 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. Generally, because consumer purchase decisions are most sensitive to purchase price increases, shipments forecasts for any standards case are lower than those under the base case.

- National Impact: The national energy consumption is calculated by multiplying the number or stock of appliance units (by vintage) by the unit energy consumption (also by vintage). Vintage is the age of the equipment. The national energy savings is calculated by subtracting energy use under a standards scenario from energy use in a base case scenario. The NPV is the sum over time of discounted net savings to appliance consumers as a result of new standards. The national NPV of any standards case is the difference between the sum of national total installed costs and operating costs in the base case and the sum of national total installed costs and operating costs in the standards case.

  A spreadsheet accounting model is used to calculate the NES and the NPV from potential new appliance efficiency standards. In using the spreadsheet model to calculate NES and NPV from new standards, weighted-average per-unit values from the life-cycle cost and payback period analysis for the total installed cost, annual energy consumption, repair cost, maintenance cost, and electricity price are used. Coupled with shipments forecasts, these inputs are used to derive the NES and NPV due to a new standard.

7. Overall Budget: N/A.

8. Status/Interim Results: In FY2004, analysis for three product types (commercial unitary air conditioners and heat pumps, distribution transformers, and residential furnaces and boilers) was completed, documented as Technical Support Documents, and published as part of Advance Notices of Proposed Rulemakings. In FY2005, analysts reviewed stakeholder comments and prepared an analysis plan for the next phase. Analysis is now in progress for Notices of Proposed Rulemakings.

IV. PROJECT ABSTRACT

1. Project Title: Appliance Standards Analysis — Manufacturer Impact Analysis (MIA)

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3. Project Schedule:

1. Initiation Date: Original project started in 1979, composed of product-specific elements. Current rulemakings started in 2001 for three product types.
2. Expected Completion Date: Current rulemakings will be completed in FY2007.

4. Statement of Problem: To qualitatively and quantitatively assess the impacts on manufacturers of potential energy efficiency standards. The qualitative assessment is based on a series of site visits and manufacturer interviews. The interviews aim to understand the engineering, operational, and financial impacts that companies would experience under regulation (changes). Quantitative information including sales impacts, financial ratios, and required capital investments are gathered during the interviews which subsequently feed into a discounted cash flow model called the Government Regulatory Impact Model (GRIM). The primary quantitative output of the GRIM is the change in Industry Net Present Value (INPV) that would be experienced under various Trial Standard Levels.

The Energy Policy Conservation Act (EPCA) provides seven factors to be evaluated in determining whether an appliance efficiency standard [energy conservation standard] is justified. (42 U.S.C. 6313(a)(6)(B)(i)) Two of these factors require the DOE to consider the economic impact on of standards on manufacturers and the impact of any lessening of competition. Both of these factors are assessed through the manufacturer impact analysis.

5. Project Objectives: The objectives of the effort during FY-2005 are to: (1) conduct the manufacturer impact interviews for high priority products (i.e., commercial unitary air conditioners, distribution transformer, and residential furnaces and boilers); (2) tailor the GRIM to each industry and obtain key metrics such as the change in INPV; and (3) provide complete documentation of each of three MIA analyses.

6. Technical Approach: The Department conducts the MIA primarily during the NOPR phase of the rulemakings. This analysis estimates the financial impact of standards on manufacturers and also calculates the impact of standards on competition, direct employment, and manufacturing capacity within the industry. Four important elements of the approach are the industry characterization, the interview process, preparation of an industry cash flow model, and the development of a sub-group cash flow analysis.

- Industry Characterization – The first step of the MIA is to collect pertinent financial and market information. Data gathered include market share, corporate operating ratios, wages, employment, and production cost ratios. The Department incorporates these data into the engineering analysis to estimate equipment production costs and markups. Sources of information typically used for this research include experts from industry as well as reports published by industry groups, trade journals, the U.S. Census Bureau, and SEC 10-K filings.

- Interview Process - The rulemaking process provides for extensive public input, with particular emphasis on earlier and more-extensive information gathering from interested parties. The interview process has a key role in the MIAs, 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. A detailed interview guide is prepared and distributed to manufacturers prior to site visits to focus and facilitate the interviews.

- Industry Cash Flow Analysis – The GRIM utilizes a number of factors such as annual expected revenues; manufacturer costs such as cost of goods sold; selling, general and administrative expenses (SG&A); property taxes; and capital expenditures to arrive at a series of annual cash flows. INPV is calculated by discounting the annual cash flows from the period before implementation of standards to some future point in time at the estimated industry weighted average cost of capital.

- Manufacturer Sub-Group 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 affected asymmetrically by standards. In highly concentrated industries it is possible to calculate the impacts on each firm. In industries having numerous participants, the results of the industry characterization are used to group manufacturers exhibiting similar characteristics. The industry GRIM serves as a benchmark against which manufacturer sub-groups are analyzed.

7. Overall Budget: N/A.

8. Status/Interim Results: In September, 1995, the Department announced a formal effort to consider further improvements to the process used to develop appliance efficiency standards. The Department called on energy efficiency groups, manufacturers, trade associations, state agencies, utilities, and other interested parties to provide input to this effort. As a result of this combined effort, the Department published *Procedures, Interpretations and Policies for Consideration of New or Revised Energy Conservation Standards for Consumer Products* (the "Process Rule"), 10 CFR 430, Subpart C, Appendix A. The process rule contains principles for the Analysis of Impacts on Manufacturers. The process rules states that the Department will utilize an annual cash flow approach to determine quantitative impacts on manufacturers including a short term assessment based on the cost and capital requirements during the period between the announcement of a regulation and the time when the regulation comes into effect. Additionally it describes how, with input from manufacturers and other interested parties, the Department will develop estimates of the critical variables affecting manufacturers (such as expected changes in product prices, sales, and possible fuel switching), drawing on multiple sources of data both quantitative and qualitative. The Department also committed to analyze the impacts of a standard on different types of manufacturers, with particular attention to impacts on small manufacturers. This analysis is to be done with scenario analysis or other appropriate methods. Finally, the Department is required to assess and describe the effects on manufacturers of other significant product-specific regulations that will take effect within three years of the effective date of the standard under consideration and will affect significantly the same manufacturers. This assessment is intended to capture the impacts of different DOE standards affecting multiple products made by the same manufacturing division.

Since publication of the process rule, three rulemaking were completed under its policies and procedures:

- Clothes Washers: Effective date = 2004
- Residential Water Heaters: Effective date = 2007
- Residential Central Air Conditioners and Heat Pumps: Effective date = 2006

In the ANOPR phase, strawman GRIM models are developed based on the industry characterization information gathered, along with draft interview guides. The MIA is a key part of the current NOPR rulemaking phase, including manufacturer interviews, GRIM refinement, and sub-group analysis.

V. PROJECT ABSTRACT

1. Project Title: Appliance Standards Analysis — Utility Impact Analysis; Environmental Assessment; Employment Impact Analysis; Regulatory Impact Analysis

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3. Project Schedule:

1. Initiation Date: Original project started in 1979, composed of product-specific elements. Current rulemakings started in 2001 for three product types.
2. Expected Completion Date: Current rulemakings will be completed in FY2007.

4. Statement of Problem: To calculate the electric and gas utility impacts, the environmental impacts, and the employment impacts due to appliances meeting potential new efficiency standards. Also, as part of a regulatory impact analysis, to calculate the effects of feasible policy alternatives to amended appliance efficiency standards.

The Energy Policy Conservation Act (EPCA) provides seven factors to be evaluated in determining whether an appliance efficiency standard [energy conservation standard] is economically justified. (42 U.S.C. 6313(a)(6)(B)(i)) One of the seven factors allows DOE to look at the non-monetary benefits of standards, such as reduced power demand (determined through the utility impact analysis) and air-borne emission reductions (determined through the environmental assessment). If power demand is reduced and air-borne emission reductions are realized due to potential new appliance efficiency standards, DOE cites these impacts as additional benefits when adopting an amended standard.

The Process Rule includes employment impacts among the factors DOE considers in selecting a proposed standard. 10 CFR Part 430, Subpart C, Appendix A.

Employment impacts consist of the total impact on employment in the national economy, including the sector that manufactures the equipment being regulated. DOE considers employment impacts when selecting an amended appliance efficiency standard.

Executive Order 12866, "Regulatory Planning and Review" requires DOE to calculate the effects of feasible policy alternatives to amended energy conservation standards. 58 FR 51735 (October 4, 1993). Each alternative is evaluated in terms of its ability to achieve significant energy savings at reasonable costs. Each alternative is compared to the effectiveness of the new appliance efficiency standard.

5. Project Objectives: The objectives of the effort during FY-2005 are to: (1) continue conducting the utility impact, environmental impact, employment impact, and regulatory impact analyses for high priority products (i.e., commercial unitary air conditioners, distribution transformer, and residential furnaces and boilers); and (2) provide complete documentation of each analysis.

6. Technical Approach:

- Utility Impact: The utility impact analysis estimates the effects of reduced energy consumption due to improved appliance efficiency on the utility industry. Specifically, the reduction in installed generation capacity (in GW) is calculated using a variant of the National Energy Modeling System (NEMS) computer model. Using national energy savings (NES) estimates from the National Impact Analysis, the NES for a given standard level are input into NEMS to forecast the impact on installed generation capacity.

- Environmental Assessment: The environmental assessment estimates the effects of reduced energy consumption due to improved appliance efficiency on air-borne emissions. The reduction in power plant and in-building emissions of CO_2, SO_2, and NO_X, is calculated using the NEMS computer model. Using national energy savings (NES) estimates from the National Impact Analysis, the NES for a given standard level are input into NEMS to forecast the impact on air-borne emissions.

- Employment Impact: National employment impacts are calculated using an input/output model of the U.S. economy, called IMBUILD. IMBUILD is a personal-computer (PC)-based, economic-analysis model that characterizes the interconnections among 35 sectors of the economy as national input/output structural matrices, using data from the Bureau of Labor Statistics. The IMBUILD model estimates changes in employment, industry output, and wage income in the overall U.S. economy resulting from changes in expenditures in the various sectors of the economy. Using changes in expenditures estimated to result from potential appliance standards (as generated by the National Impact Analysis), IMBUILD estimates the net national effect of such standards on employment by sector.

- Regulatory Impact: The national energy savings and consumer net present value of non-regulatory alternatives are calculated with the spreadsheet accounting model developed for the National Impact Analysis. Inputs to the spreadsheet model are modified to analyze the non-regulatory measures being considered.

7. Overall Budget: N/A.

8. Status/Interim Results: In FY2004, analysis for three product types (commercial unitary air conditioners and heat pumps, distribution transformers, and residential furnaces and boilers) was completed, documented as Technical Support Documents, and published as part of Advance Notices of Proposed Rulemakings. In FY2005, analysts reviewed stakeholder comments and prepared an analysis plan for the next phase. Analysis is now in progress for Notices of Proposed Rulemakings.

PROJECT DESCRIPTIONS

PROJECT DESCRIPTION

1. Project Title: U.S. DOE Energy Conservation Standards: Screening Analysis; Engineering Analysis

2. Principal investigator:

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3. Other Participating Organizations: Project Managers, U.S. Department of Energy

4. Project:

Distribution Transformers:

1. Schedule
   - a: Initiation Date: November 1, 2000
   - b: Dates of Intermediate Phase Completions or Go/No-Go Points: Advance Notice of Proposed Rulemaking (ANOPR) published July 29, 2004; ANOPR Public Meeting on September 28, 2004; ANOPR Comment Period ended November 9, 2004.
   - c: Original Expected Completion Date: "The Regulatory Plan and the Unified Agenda of Federal Regulatory and Deregulatory Actions" (69 FR 72712-72713) (commonly referred to as the *Regulatory Agenda*) calls for the Notice of Proposed Rulemaking (NOPR) to be published in September, 2006. It is scheduled to be published in September, 2006. Prior to publishing the NOPR, the *Regulatory Agenda* calls for a Technical Support Document (TSD) to be reviewed by the Department by September, 2005.
2. Funding Status: NCI is under subcontract with Research and Development Solutions (RDS), LLC, under the RDS Prime Contract with the National Energy Technology Laboratory (NETL).
3. Project/technology maturity – Analysis

   The focus of the Distribution Transformers standards rulemaking is to publish a Final Rule that promulgates energy conservation standards for this product. As part of the rulemaking, in-depth technical analyses are conducted and published, detailing the impacts of potential efficiency standards on production costs (i.e., cost to manufacture), consumer life-cycle cost, national energy savings, and manufacturer profitability, environmental impacts, and national employment.

Residential Furnaces and Boilers:

1. Schedule
   a: Initiation Date: July 17, 2001
   b: Dates of Intermediate Phase Completions or Go/No-Go Points: Advance Notice of Proposed Rulemaking (ANOPR) published July 29, 2004; ANOPR Public Meeting on September 29, 2004; ANOPR Comment Period ended November 10, 2004.
   c: Original Expected Completion Date: "The Regulatory Plan and the Unified Agenda of Federal Regulatory and Deregulatory Actions" (69 FR 72712-72713) (commonly referred to as the *Regulatory Agenda*) calls for the Notice of Proposed Rulemaking (NOPR) to be published in September, 2006. It is scheduled to be published in September, 2006. Prior to publishing the NOPR, the *Regulatory Agenda* calls for a Technical Support Document (TSD) to be reviewed by the Department by September, 2005.
2. Funding Status: NCI is under subcontract with Research and Development Solutions, (RDS), LLC, under the RDS Prime Contract with NETL.
3. Project/technology maturity – Analysis
   The focus of the Residential Furnaces and Boilers standards rulemaking is to publish a Final Rule that promulgates energy conservation standards for this product. As part of the rulemaking, in-depth technical analyses are conducted and published, detailing the impacts of potential efficiency standards on production costs (i.e., cost to manufacture), consumer life-cycle cost, national energy savings, and manufacturer profitability, environmental impacts, and national employment.

5. Statement of Problem:

The Energy Policy and Conservation Act (EPCA) provides criteria for prescribing new or amended standards which will achieve the maximum improvement in energy efficiency, which the Secretary of Energy determines is technologically feasible and economically justified, and establishes guidelines for determining whether a standard is economically justified. 42 U.S.C. 6313(a)(6)(A).

Screening Analysis

In view of the above EPCA requirements for determining whether a standard is technologically feasible and economically justified, Appendix A to subpart C of Title 10 Code of Federal Regulations Part 430 (10 CFR Part 430), "Procedures, Interpretations and Policies for Consideration of New or Revised Energy Conservation Standards for Consumer Products," (the process rule) sets forth procedures to guide the Department of Energy in the consideration and promulgation of new or revised appliance efficiency standards under EPCA.

Screening factors described in the process rule elaborate on the statutory criteria provided in 42 U.S.C. 6295 and in part seek to eliminate problematic design options early in the process of revising an energy efficiency standard. Under the guidelines, DOE eliminates from consideration design options that present unacceptable problems with respect to the following four factors:

- technological feasibility;
- practicability to manufacture, install and service;
- adverse impacts on equipment utility to consumers or availability; and
- adverse impacts on health or safety.

The Department will not consider a technology that does not meet any one of the above guidelines. 10 CFR Part 430, subpart C, appendix A, at paragraph 5(b).

Engineering Analysis

When DOE is determining the economic justification for its standards, EPCA directs it to consider a number of different factors, including the economic impact of potential standards on consumers and manufacturers. The engineering analysis develops cost-efficiency relationships, estimating manufacturer costs of achieving increased efficiency levels. Manufacturing costs are used as the basis for determining retail prices in the life-cycle cost analysis, and are needed for the manufacturer impact analysis. The engineering analysis also determines the maximum technologically feasible efficiency level.

In general, the engineering analysis estimates the efficiency improvement potential of the design options that pass the screening analysis criteria. In consultation with stakeholders, the Department uses the most appropriate method to determine the relationship between manufacturer's costs and increasing energy efficiency. There are three general methods for developing manufacturing cost-efficiency curves: the efficiency-level approach, the design-option approach, and the cost-assessment approach.

The Department is directed to consider designs that achieve the maximum improvement in energy efficiency that the Secretary determines are technologically feasible and economically justified. (42 U.S.C. 6295(o)(2)(A)) Therefore, an important role of the engineering analysis is to identify the maximum technologically feasible level. The maximum technologically feasible level is one that can be reached through efficiency improvements and/or design options, both commercially feasible and in prototypes. The Department believes that the design options comprising the maximum technologically feasible level must have been physically demonstrated in at least a prototype form to be considered technologically feasible.

6. Project Objectives:

This project is designed to satisfy the legislative mandate for DOE to analyze appliance efficiency standards. The screening analysis and the engineering analysis serve to identify the maximum technologically feasible designs. The cost-efficiency relationship developed in the engineering analysis is the underpinning of the consumer LCC analysis which is essential to determine consumer impacts. The costs developed in the engineering analysis are also a critical input to the manufacturer impact analysis.

7. Project History & Relationships:
This project has been a key component of DOE's energy efficiency standards rulemakings since 1979, and a critical part of the current rulemakings being analyzed by the Building Technologies Program (BTP)—including the Distribution Transformer standards rulemaking and the Residential Furnaces and Boilers standards rulemaking.

The Screening and Engineering analyses are two of the elements required for performing a full appliance standards analysis. These analyses precede and provide input to the life-cycle cost (LCC) analysis and the manufacturer impact analysis.

8. Technical Approach:
Screening Analysis: The Department develops, with input from interested parties, a list of design options for further consideration. The Department eliminates from further consideration a design option that: Is not technologically feasible; is not practicable to manufacture, install and service; has significant adverse impact on the utility of the product to consumers; or adversely affects health or safety. Consistent with Natural Resources Defense Council v. Herrington, 768 F.2d 1355 (D.C. Cir. 1985), the Department evaluates design options for technological feasibility on the basis of whether the options are in use by industry or research has progressed to the development of a prototype. However, consideration of practicability to manufacture, impacts on consumer utility and health and safety effects at this stage is designed to ensure that commercially impractical designs, even if technologically feasible, are screened out on the basis of other statutory criteria early in the process. This early screening approach reduces uncertainty as to the direction of standards development. The screening process includes consultations with interested parties and independent technical experts who can assist with identifying the key issues and design options or efficiency levels. The screening analysis also discusses the criteria for eliminating certain design options or efficiency levels from further consideration. By comparing the design options or efficiency levels against these criteria, the Department eliminates from further analysis those options or efficiency levels that are not sufficiently developed or have characteristics that make them technologically unsuitable for consideration in the rulemaking. The Department will consider in the analyses, wherever feasible, data, information and analyses received from stakeholders.

Engineering Analysis: In consultation with outside experts, the Department selects the specific engineering analysis tools to be used in the evaluation. There are three general approaches for developing cost-efficiency schedules: the "efficiency level approach," the "design option approach," and the "cost assessment approach." The critical inputs to the engineering analysis are data from manufacturers and/or experts in designing and costing appliances and commercial equipment. This includes the cost-efficiency information available through retail prices and their existing efficiencies. However, information is also required to estimate, for some products, cost-efficiency tradeoffs that may not be available from current market information. This type of information may be developed by manufacturers, from simulation models and/or by design experts.

9. Technical Work Plan:

Screening Analysis
The DOE typically uses information relating to existing and past technology options and prototype designs 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, these technologies encompass all those considered to be technologically feasible.

The Department develops its list of technologically feasible design options on consultation with manufacturers of components and systems, and with 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.

It then applies the following set of screening criteria to determine which design options are unsuitable for further consideration in the rulemaking (10 CFR Part 430, Subpart C, Appendix A at 4(a)(4) and 5(b):

Technological feasibility. Technologies incorporated in commercial products or in working prototypes will be considered technologically feasible;

Practicability to manufacture, install, and service. If mass production of a technology in commercial products and reliable installation and servicing of the technology could be achieved on the scale necessary to serve the relevant market at the time of the effective date of the standard, then that technology will be considered practicable to manufacture, install and service.

Adverse impacts on product utility or product availability. If a technology is determined to have significant adverse impact on the utility of the product to significant subgroups or consumers, or result in the unavailability of any covered product type with performance characteristics (including reliability), features, sizes, capacities, and volumes that are substantially the same as products generally available in the U.S. at the time, it will not be considered further.

Adverse impacts on health or safety. If it is determined that a technology will have significant adverse impacts on health or safety, it will not be considered further.

The Department initially prepares a draft screening analysis and presents it for review and comment at the Framework Rulemaking Workshop.

Engineering Analysis
The Department considers the availability of data and analytical tools, the resource needs and public comments when determining the best approach or combination of approaches

for an engineering analysis. In general, three methodologies are used to generate the manufacturing cost-efficiency relationships:

1. the efficiency-level approach - reporting relative costs of achieving energy efficiency improvements;
2. the design-option approach - reporting the incremental costs of adding design options to a baseline model; and
3. the cost-assessment approach (or reverse engineering approach) - involves a "bottoms-up" manufacturing cost assessment based on a detailed bill of materials derived from transformer tear-downs.

Each of these approaches is described in some detail below.

The efficiency-level approach establishes the relationship between manufacturer's cost and increased efficiency at incrementally higher efficiency levels. Manufacturers may provide incremental cost data for these increases, or alternatively, retail price surveys can be used to obtain information on existing products at known efficiency levels. Cost-efficiency (or price-efficiency) curves can be easily constructed from the information gathered.

The simplicity of the efficiency-level approach is also its primary drawback. Namely, since technological details are often not provided, it can be difficult to verify whether the manufacturer costs given for each efficiency level are truly representative of the costs for that level. In addition, prototype designs are difficult to evaluate, making it difficult to establish maximum technologically feasible design costs. As a result, some type of supplementary analysis is often needed in order to verify the accuracy of the costs obtained through the efficiency-level approach.

The design-option approach identifies individual or combinations of design options which increase efficiency. These increases in efficiency are typically either based on manufacturer or component supplier estimates or on engineering computer simulation models. The incremental manufacturing costs of adding design options to a baseline model are then determined. The Department adds individual or combinations of design options to the baseline model in ascending order of cost-effectiveness. Typically, the payback period is used to establish a design option's cost-effectiveness and is determined by the ratio of the change in total consumer cost to the change in operating cost.

The primary advantage of the design-option approach is its ability to analyze individual technologies. The approach is transparent in that the impact of any single technology on cost and efficiency is explicit. An additional advantage is its ability to incorporate designs that have been demonstrated to perform in prototypes but have yet to be utilized in equipment currently available on the market. Thus, maximum technologically feasible designs are more easily established than in the efficiency-level approach.

Although individual technologies can be assessed, the design-option approach tends to be complex. The material combinations considered may be combined in ways not typically utilized by manufacturers, making it difficult to assess the impact of a design on system cost and efficiency. In order to determine a technology's impact on system efficiency, computer simulation models are typically employed, but these models exhibit at least some level of inaccuracy, and only approximate the performance of actual manufactured units.

The cost-assessment approach, also called the 'reverse engineering approach,' is centered around a component-based technology-costing of the various technological paths manufacturers typically use to achieve increased product energy efficiency. Under this type of analysis, DOE physically analyzes, i.e., dismantles actual pieces of commercially available equipment, component-by-component to determine what technologies and designs manufacturers employ to increase efficiency. The Department then uses independent costing methods and manufacturer and component supplier data to estimate the costs of the components. This approach has the distinct advantage of using "real" market equipment to establish the technologies that are used by manufacturers and to establish the manufacturing cost to produce more-efficient units.

The primary disadvantage of reverse engineering is the time and effort required to analyze the 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, prototype designs may not be captured by the analysis, thus making it difficult to establish maximum technologically feasible designs.

The transformer engineering analysis was performed using the design option approach. The Department structured the engineering analysis around 13 groupings (termed 'engineering design lines') of similarly built distribution transformers. The Department then identified one representative unit from each grouping and conducted software design runs on those units. The design software was used to create a database of distribution transformer designs spanning a range of efficiencies, while tracking all the modifications to the core, coil, labor, and other key cost components. The Department selected software developed by an independent company not associated with any one manufacturer or manufacturer's association. As a supplement to the design option analysis, the Department conducted cost-assessment (reverse engineering) on one of the 13 design lines to verify construction practices and validate the design software.

The engineering analysis for residential furnaces and boilers was performed using the cost-assessment approach. The approach was applied in conjunction with a review of relevant literature, computer simulation, and other analytical approaches. In some cases, industry-supplied data was adopted. The availability of a vast selection of residential products, which span several efficiency levels, allowed for reverse engineering methods as the basis for estimating production costs. DOE purchased and disassembled the selected units, carefully analyzing each part. Additionally, DOE studied and reconstructed all the steps of the manufacturing processes to complete the tear-down analysis. The result was a detailed bill of materials to enter into the cost model.

Since DOE did not capture all possible efficiency levels of each product class from the sample units used in the tear-down analysis, DOE took the following steps to create bill of materials for additional efficiency levels: (1) identify efficiency gaps; (2) select most promising design options; (3) identify possible design modifications of existing units and create a written description of "hypothetical" (or "theoretical") units; (4) perform simulations to correlate design modifications with efficiency levels; and (5) create bills of materials for "hypothetical" units.

10. Technical Problems/Barriers:

Screening Analysis

- Evaluating Design Options: An initial list of design options is developed from the technologies identified during the technology assessment. Following the development of this initial list of design options, the Department, in consultation with interested parties, reviews each design option to determine if it is practicable to manufacture, install and service; would adversely impact equipment utility or equipment availability; or would have adverse impacts on health and safety. The information needed to conduct the information is frequently difficult to obtain and/or is proprietary.

Engineering Analysis

- Establishing Product Classes: Products may be separated into product classes if their capacity or other performance-related features or attributes including those that provide utility to the consumer and affect efficiency and as such warrant the application of individual energy-efficiency standards. Such different standards would then be formulated for the different product classes. In general, classes are defined using information obtained in discussions with manufacturers, trade associations, and other interested parties. Determining the need and defining product classes is often difficult.
- Baseline Units: A baseline model is established as a reference point for each product class against which changes that would be brought about by energy conservation standards can be measured. Typically a baseline model would be a model that just meets required energy conservation standards. After the product classes are chosen, the characteristics of the baseline model for each class are defined. The baseline model is used in the life-cycle cost and payback analyses. To determine energy savings and change in price, each higher efficiency design option is compared with the baseline model. It is frequently difficult to establish a baseline model that is representative of an entire product class particularly where baseline models vary by manufacturer. The difficulty is amplified when there is no existing minimum efficiency standard (e.g., distribution transformers).
- Energy Performance Models: In order to determine a technology's impact on system efficiency, a computer simulation model is often employed. Since computer simulation models exhibit at least some level of inaccuracy, time and effort must be expended to validate the model's results. Equipment simulation models may demand detailed input balanced by the need to protect manufacturers and component suppliers proprietary design strategies. Also, equipment

performance data at specified test conditions must be supplied in order to validate the model's performance.

- Estimating Manufacturing Costs: The cost estimates used in the engineering analysis often have the following, sometimes competing, characteristics: (1) a level of transparency that permits validation by outside parties; (2) a level of detail that permits outside parties to draw conclusions regarding the design choices underlying the analysis; and (3) protection of sensitive or confidential design or costing information.
- Reflecting Variability: The manufacturer cost information derived in a component-based analysis can not completely reflect the variability in baseline units, design strategies and cost structures that often exists between different manufacturers.

11. Status of Milestones:

For the standards rulemakings discussed here—distribution transformers and residential furnaces and boilers. Screening and engineering analyses were conducted for each product's Advance Notice of Proposed Rulemaking (ANOPR). Both the distribution transformers and residential furnaces and boilers ANOPRs were published on July 29, 2004.

According to the *Regulatory Agenda*, the NOPRs for distribution transformers and residential furnaces and boilers are both scheduled to be published in September, 2006. Prior to publishing the NOPRs, the *Regulatory Agenda* calls for TSDs to be reviewed by the Department by September, 2005. Because TSDs are required to be completed and reviewed by September, 2005, the Screening and Engineering analyses had to be revised by May, 2005. Both of these analyses have been completed.

12. Efficiency Improvement Metrics:

There are ten product classes of DT that are being analyzed, consisting of thirteen design lines. The ten product classes are divided into classes of liquid-type transformers, typically used by electric utilities, and dry-type transformers, which are typically used at commercial and industrial building sites. The energy descriptor for DT is *efficiency*, which measures the total energy losses at a design load of 50 percent for liquid-type transformers and 35 percent for dry-type transformers. The cost of achieving higher transformer efficiency varies significantly over the product classes. The purpose of the NES/NPV part of the national impact spreadsheet is to calculate some of the key quantities by which a candidate energy efficiency standard may be evaluated. Two such quantities are national source energy savings and NPV. Source energy is total energy saved (or reduction in losses) by transformers. NPV is a measure of the net benefit to consumers due to an energy-efficiency standard.

13. Project Output:
Major Accomplishments:

For distribution transformers, the major accomplishments are the publication of the Technical Support Document and the Analytical Spreadsheets that accompanied the ANOPR:

- U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy, *Technical Support Document: Energy Efficiency Program for Commercial and Industrial Equipment: Electrical Distribution Transformers*, July, 2004. Washington, DC. <http://www.eere.energy.gov/buildings/appliance_standards/commercial/dist_trans_tsd_061404.html>
- U.S. Department of Energy-Office of Energy Efficiency and Renewable Energy, ANOPR Analytical Spreadsheets, ANOPR engineering analysis results spreadsheets for all 13 design lines, April 2004. Washington, DC. <http://www.eere.energy.gov/buildings/appliance_standards/commercial/distribution_transformers_spreadsheets.html>

For FB, the major accomplishments are the publication of the Technical Support Document and the Analytical Spreadsheets that accompanied the ANOPR:

- U.S. Department of Energy-Office of Energy Efficiency and Renewable Energy, *Technical Support Document: Energy Efficiency Program for Consumer Products: Energy Conservation Standards for Residential Furnaces and Boilers*, September, 2004. Washington, DC. < http://www.eere.energy.gov/buildings/appliance_standards/residential/furnaces_boilers_1113_r.html>
- U.S. Department of Energy-Office of Energy Efficiency and Renewable Energy, Residential Furnaces and Boilers ANOPR Analytical Tools, September, 2004. Washington, DC. <http://www.eere.energy.gov/buildings/appliance_standards/residential/furnace_boiler_draft_analysis.html>

14. Principal Project Personnel:

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- *Role in the project*: Principal Investigator
- *Principal areas of research and expertise*: Financial analysis and valuation, market and technology analysis, and strategic planning. Assisted the Department of Energy in the development of new policies and procedures to review and update energy efficiency regulations for residential and commercial appliances. Managed the collaborative development of a new economic impact analysis methodology to determine the likely impacts of appliance standards on appliance and equipment manufacturers. Directed the manufacturer impact analyses for

fluorescent lamp ballasts, clothes washers, water heaters, and central air conditioners.

- *Percentage of time devoted to the project*: 10%
- *Education*: Master of Science, Technology and Policy, MASSACHUSETTS INSTITUTE OF TECHNOLOGY**;** Master of Business Administration, CONCORDIA UNIVERSITY; Bachelor of Engineering, Electrical Engineering, McGILL UNIVERSITY.
- *Relevant professional employment history*: Central Plumbing and Electricity Ltd, Director - Electrical Contracting (1982 to 1986); The Centco Group Inc, President (1986 to 1994); Arthur D. Little Inc, Director (1995 to 2002); Navigant Consulting Inc, Managing Director (2002-present).
- *Relevant professional activities and honors*: President 1994-1995, Vice-President 1992-1993, Quebec Natural Gas Association; Board Member 1993-1994, Natural Gas Technology Center (Quebec); Board Member 1991-1994, Provincial Council for Training in the Construction Industry (Quebec); Board Member 1991- 1994, Centre Antonio-Barrette Trade School; Member, Training committee of the Quebec Association of Consulting Engineers 1993; Member, Gas Utility-Contractor joint committee on appliance servicing.

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- *Role in the project*: Project Manager, Distribution Transformers
- *Principal areas of research and expertise*: Developing energy performance standards for commercial and residential equipment, as well as studying market barriers and transformation activities for energy efficient products.
- *Percentage of time devoted to the project*: 33%
- *Education*: Master of Science, Civil and Environmental Engineering, Bachelor of Science, Mechanical Engineering and Environmental Studies, TUFTS UNIVERSITY.
- *Relevant professional employment history:* International Institute for Energy Conservation-Europe, Project Manager, (1994 to 1996); International Institute for Energy Conservation-Africa, Program Manager, (1997 to 1999); PW Consulting, Database Analyst**,** (1999 to 2000); Arthur D. Little, Inc., Consultant, (2000 to 2002); Navigant Consulting, Inc, Managing Consultant, (2002 to Present).
- *Relevant professional activities and honors:*
    - *Certificate of Appreciation*, United States Department of Energy, Bill Richardson, Secretary of Energy, for exemplary contribution in support of the Lighting and Appliance Standards Program, December 2000
    - Member, Tau Beta Pi (national engineering honors society)
    - Association of Energy Engineers scholarship, Boston Chapter
- *Relevant publications not emanating from this project*:

- *Analyzing Barriers and Designing Market Transformation Programs for Energy Efficient Technology*, co-author, 2004 ACEEE Summer Study on Energy Efficiency in Buildings, Pacific Grove, California, August 2004
- *Energy Savings Estimates of Light Emitting Diodes in Niche Lighting Applications*, co-author, 2004 ACEEE Summer Study on Energy Efficiency in Buildings, Pacific Grove, California, August 2004
- *Technical Support Document: Energy Efficiency Program for Commercial and Industrial Equipment: Energy Conservation Standards for Distribution Transformers*, co-author, July 2004.
- *Energy Savings Potential of Solid-State Lighting in General Illumination Applications*, report author, prepared for the U.S. Department of Energy, November 2003
- *U.S. Lighting Market Characterization, Volume I: National Lighting Inventory and Energy Consumption Estimate*, report co-author, prepared for the U.S. Department of Energy, September 2002
- *Appliance Efficiency Standards Take Off*, Vital Signs 2002, Worldwatch Institute, Washington, D.C., May 2002

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- *Role in the project*: Project Manager, Distribution Transformers
- *Principal areas of research and expertise*: Development of energy efficiency standards for consumer products and commercial equipment, as well as analyzing renewable energy technologies and markets.
- *Percentage of time devoted to the project*: 33%
- *Education*: Master of Science, Technology and Policy, MASSACHUSETTS INSTITUTE OF TECHNOLOGY; Master of Science, Environmental Engineering, CLEMSON UNIVERSITY; Bachelor of Science, Chemical Engineering, BUCKNELL UNIVERSITY
- *Relevant professional employment history*: Massachusetts Institute of Technology, Researcher, (1999 to 2001); Antares Group, Inc., Project Manager, (2001 to 2003); Navigant Consulting, Inc., Senior Consultant, (2003 to present).
- *Relevant professional activities and honors*: Recipient of Oak Ridge Institute for Science and Education Fellowship (1997); Martin Sustainability Fellow, MIT (2000).
- *Relevant publications not emanating from this project*:
  - Fjeld, R.A., S.M. Serkiz, B.W. Gibbs, P.L. McGinnis, J.T. Coates. "Evaluation of a Conceptual Model for the Subsurface Transport of Plutonium Involving Surface Mediated Reduction of Pu(V) to Pu(IV)." Paper presented at the 8th International Conference on Chemistry and Migration Behaviour of Actinides and Fission Products in the Geosphere, Bregenz, Austria (2001). Results of laboratory analysis originally presented at the 1998 Health Physics Society's annual conference in Minneapolis, MN.

- Gibbs, Barclay and Bruce Biewald, "Transmitting Windpower from the Dakotas to Chicago: A Preliminary Analysis of a Hydrogen Transmission Scenario." Paper presented at the 12th Annual Meeting of the US National Hydrogen Association, the Annual Meeting of the American Wind Energy Association (2001), the World Congress for a Hydrogen Economy (Denver, 2001), and the First International Conference for the Hydrogen Century (Tokyo, 2001).
- Gibbs, Barclay, 2001, "Increasing the Gasoline Tax in Mexico City: A Potential Policy Option to Supplant Early Implementation of Tier 2 Tailpipe Standards," Masters Thesis, Massachusetts Institute of Technology. Contribution to forthcoming MIT publication.

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- *Role in the project*: Project Manager, Residential Furnaces and Boilers, Cost Modeling
- *Principal areas of research and expertise*: Design for assembly, inventory control, manufacturing line layout, reliability, cost reduction, technical cost modeling, quality control, plant siting, lifecycle costing, high-volume processing, reverse engineering, tooling design, and evaluation of capital equipment.
- *Percentage of time devoted to the project*: 10%
- *Education*: Master of Science, Manufacturing Engineering, UNIVERSITY OF RHODE ISLAND; Bachelor of Science, Physics, YALE UNIVERSITY.
- *Relevant professional employment history*: Thermal Ceramics, Process Engineer, (1992 –1993); Wesgo Ceramics, Process Engineer, (1995-1996); Powis Parker, Inc., Manufacturing Engineer, (1997 – 1998); TIAX LLC (formerly Arthur D. Little, Inc.), Consultant (1999 – 2002); Navigant Consulting, Senior Consultant (2002 to present).
- *Relevant professional activities and honors*:
  - US Patents: 5645627, Charge stabilized electret filter media; 6609274, Refrigerator Handle Assembly; 6780226, Charge stabilized electret filter media.

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- *Role in the project:* Project Manager, Residential Furnaces and Boilers
- *Principal areas of research and expertise:* Energy efficiency of mechanical equipment and technical analysis and evaluation of consumer products and commercial equipment.
- *Percentage of time devoted to the project:* 25%

- *Education:* PhD, Mechanical Engineering, UNIVERSITY OF MARYLAND COLLEGE PARK; Master of Engineering, Engineering Management, CATHOLIC UNIVERSITY OF AMERICA; Bachelor of Science, Mechanical Engineering, UNIVERSITY OF MARYLAND COLLEGE PARK.
- *Relevant professional employment history*: General Services Administration, Mechanical Engineer, (1992 to 1999); Center for Environmental Energy Engineering, University of Maryland College Park, Manager of the Building Cooling, Heating and Power Project, (1999 to 2002); Navigant Consulting, Inc., Senior Consultant, (2002 to present).
- *Relevant professional activities and honors:* American Society of Heating, Refrigeration, and Air-Conditioning Engineers Member; Association of Energy Engineers Foundation Scholarship; UT-Battelle Educational Institution of the Year Award, BCHP project in support of Oak Ridge National Laboratory; GSA Regional Administrator's Enterprise Award; Tau Beta Pi National Engineering Honor Society Member.
- *Relevant publications not emanating from this project:*
    - Marantan, A., "Optimization of Integrated Microturbine and Absorption Chiller Systems in CHP for Buildings Applications," Doctoral Dissertation, University of Maryland, College Park, December, 2002.
    - Wongsosaputro, W., A. Marantan, P. Popovic, P. Garland and R. Radermacher, *"Environmental Analysis of Two Cooling, Heating and Power Systems for Commercial Buildings,"* Energy Journal, 2002.
    - Cowie, M., A. Marantan, P. Garland, and R. Radermacher, *"CHP for Buildings: The Challenge of Delivering Value to the Commercial Sector,"* 2002 Proceedings of the ASME International Mechanical Engineering Congress and Exposition, Vol. 3 (IMECE2002), New Orleans, LA, November, 2002.
    - Popovic, P., A. Marantan, R. Radermacher and P. Garland, *"Integration of a Microturbine with a Single Effect Exhaust Driven Absorption Chiller and a Solid Wheel Desiccant System,"* ASHRAE Symposium on CHP for Buildings, ASHRAE Transactions 2002, Vol 108, Pt. 2.
    - Marantan, A., P. Popovic and R. Radermacher, *"The Potential of CHP Technology in Commercial Buildings - Characterizing the CHP Demonstration Building,"* ASHRAE Symposium on CHP Technologies for the New Century, ASHRAE Transactions 2002, Vol 108, Pt. 1.
    - Popovic, P., D. Lindsay, A. Marantan and R. Radermacher, *"Investigation of the Cost and Feasibility of the Development of Renewable Energy Projects in the State of Maryland,"* Baltimore Gas & Electric, September 2000.

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- *Role in the project*: Ensure compliance to Federal legislation governing efficiency standards and to administrative law, including the Administrative Procedures Act.
- *Principal areas of research and expertise*: Mr. Levy has worked on a range of projects on energy conservation regulation for the Department of Energy, including public notices setting forth new compliance and enforcement methods and procedures for commercial products, proposing new test methods and procedures for commercial products, proposing new test methods for distribution transformers, and addressing regulation of products not previously covered under the Department's programs.
- *Percentage of time devoted to the project*: 10%
- *Education*: Bachelor of Law, UNIVERSITY OF MICHIGAN LAW SCHOOL; Bachelor of Arts, Political Science, BROOKLYN COLLEGE.
- *Relevant professional employment history*: Department of Energy, Economic Regulatory Administration, Assistant Special Counsel for Settlements (1985 to 1987); Department of Energy, Economic Regulatory Administration, Senior Trial Attorney (1987 – 1995); Department of Energy, Office of Assistant General Counsel for Energy Efficiency, Attorney, (1995 – 2000), Arthur D. Little, Inc., Consultant (2001 – 2002); Navigant Consulting, Inc., Managing Consultant (2002-present).
- *Relevant professional activities and honors*:
    - Member of the Bar in the District of Columbia and New York State
    - Cash Award for Special Service, as Acting Deputy Director of the Office for Civil Rights, Department of Health, Education and Welfare (HEW), June 1979
    - Superior Service Award from the Secretary of HEW, October 1970

Paul K. Goethe, President and CEO, Optimized Program Service, Inc.

- *Role in the project*: Development of a database of transformer designs, with varying costs and efficiencies.
- *Principal areas of research and expertise*: Transformer design and testing.
- *Percentage of time devoted to the project*: 5%
- *Education*: Bachelor of Science, Electrical Engineering, MICHIGAN TECHNICAL UNIVERISTY; Continued graduate studies through Westinghouse sponsored advanced degree programs conducted by The University of Pittsburgh and Penn State from 1950 through 1958.
- *Relevant professional employment history*: Westinghouse, Test Engineer (1949); Westinghouse, Design Engineer, Supervising Engineer and Engineering Manager (1950-1958); Electronic Devices, Inc., Co-founder, Vice President and General Manager (1959-1969); Optimized Program Service, Inc., founder, President and CEO, (1969-present).
- *Relevant professional activities and honors*:
    - I.E.E.E. – functioned as Westinghouse representative on various standard committees. For the past thirty two years have been active in I.E.E.E.

standards development and served as National Chairman of E.T.T.C. under the auspices of the Magnetic Society and Power Electronics Society.

David A. Wiegand, P.E. Transformer Engineering Services.

- *Role in the project*: Technical consultant on transformer design, construction methods, design optimization and testing.
- *Principal areas of research and expertise*: Transformer design and manufacturing.
- *Percentage of time devoted to the project*: 5%
- *Education*: Bachelor of Science, Electrical Engineering – Power Option (Honors), University of Toronto.
- *Relevant professional employment history*: Ferranti-Packard, Reliance, and McGraw-Edison, Design Engineer (1954-1963); Westinghouse, Marketing Product Manager (1963-1974); Westinghouse, Supervisor-Design Engineering, (1974-1981); Westinghouse and ABB, Product Specialist-Transformers, (1981-1991); Transformer Engineering Services, President and CEO, (1991 to present).
- *Relevant professional activities and honors*: PEO (Professional Engineers, Ontario); IEEE Life Member; IEEE Standards Association-Transformers; CSA Chair, Technical Committee on Industrial Equipment; CSA Chair, Subcommittee on Liquid-Filled Distribution Transformer Efficiency; CSA Chair, Subcommittee on Dry-Type Transformer Efficiency
- *Relevant publications not emanating from this project:*
  - *Utility Application of Dry-Type Transformers*, MEA Project 1998
  - *Secondary Spade Connections on Pad-mounted and Vault-Installed Transformers*, MEA Project 1996
  - *A Review of the Basis of Existing Requirements for Clearances Between Padmount Transformers and Building Structures*, MEA Project 1993
  - *A Review of Research into Standard Requirements for Clearance between Three Phase Pad-Mounted Transformers and Adjacent Building Structures*, MEA Project 1995
  - *CEA Position Paper SD-286a: Replacement of Electric Insulating Oil in Distribution Equipment*, 1994
  - *Control of Transformer Losses in Canada*, IEEE 1994, Chicago

15. Other Information Sources:

More information on the project can be found on the following websites:

- http://www.eere.energy.gov/buildings/appliance_standards/commercial/distribution_transformers.html
- http://www.eere.energy.gov/buildings/appliance_standards/residential/furnaces_boilers.html
- http://eappc76.lbl.gov/tmacal/ees.cfm

PROJECT DESCRIPTION

1. Project Title: U.S. DOE Energy Conservation Standards: Markup, Life-Cycle Cost (LCC), and LCC Subgroup Analyses

2. Principal investigator:

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3. Other Participating Organizations: Michael Rivest, Navigant Consulting; and Project Managers, U.S. Department of Energy

4. Project:

Distribution Transformers:

1. Schedule
   - a: Initiation Date: October 1, 2000
   - b: Dates of Intermediate Phase Completions or Go/No-Go Points: Advance Notice of Proposed Rulemaking (ANOPR) published July 29, 2004; ANOPR Public Meeting on September 28, 2004; ANOPR Comment Period ended November 9, 2004
   - c: Original Expected Completion Date: "The Regulatory Plan and the Unified Agenda of Federal Regulatory and Deregulatory Actions" (69 FR 72712-72713) (commonly referred to as the *Regulatory Agenda*) calls for the Notice of Proposed Rulemaking (NOPR) to be published in September, 2006. It is scheduled to be published in September, 2006. Prior to publishing the NOPR, the *Regulatory Agenda* calls for a Technical Support Document (TSD) to be reviewed by the Department by September, 2005.
2. Funding Status: Appliance Standards projects are currently awarded on a non-competitive basis.
3. Project/technology maturity – Analysis

   The focus of the Distribution Transformers standards rulemaking is to publish a Final Rule that promulgates energy conservation standards for this product. As part of the rulemaking, in-depth technical analyses are conducted and published, detailing the impacts of potential efficiency standards on production costs (i.e., cost to manufacture), consumer life-cycle cost, national energy savings, and manufacturer profitability, air-borne emissions, and national employment.

Residential Furnaces and Boilers:

1. Schedule
   a: Initiation Date: October 1, 2000
   b: Dates of Intermediate Phase Completions or Go/No-Go Points: : Advance Notice of Proposed Rulemaking (ANOPR) published July 29, 2004; ANOPR Public Meeting on September 29, 2004; ANOPR Comment Period ended November 10, 2004
   c: Original Expected Completion Date: "The Regulatory Plan and the Unified Agenda of Federal Regulatory and Deregulatory Actions" (69 FR 72712-72713) (commonly referred to as the *Regulatory Agenda*) calls for the Notice of Proposed Rulemaking (NOPR) to be published in September, 2006. It is scheduled to be published in September, 2006. Prior to publishing the NOPR, the *Regulatory Agenda* calls for a Technical Support Document (TSD) to be reviewed by the Department by September, 2005.
2. Funding Status: Appliance Standards projects are currently awarded on a non-competitive basis
3. Project/technology maturity – Analysis
   The focus of the Residential Furnaces and Boilers standards rulemaking is to publish a Final Rule that promulgates energy conservation standards for this product. As part of the rulemaking, in-depth technical analyses are conducted and published, detailing the impacts of potential efficiency standards on production costs (i.e., cost to manufacture), consumer life-cycle cost, national energy savings, and manufacturer profitability, air-borne emissions, and national employment.

5. Statement of Problem:

The Energy Policy and Conservation Act (EPCA) specifies that any new or amended energy conservation standard for consumer products shall be designed to achieve the maximum improvement in energy that is technologically feasible and economically justified. Furthermore, when DOE is determining the economic justification for its standards, EPCA directs it to consider a number of different factors, including the economic impact of potential standards on consumers. To address these provisions, the Department must determine changes in life-cycle costs (LCCs) to consumers that would likely result from a proposed standard. In addition, it is important that DOE evaluates impacts on any identifiable groups of consumers who may be disproportionately affected by any national energy-efficiency standard level. To carry out the necessary LCC and LCC sub-group calculations, DOE must determine the cost to the consumer of both baseline and more-efficient units; since the consumer price of such units is not generally known, DOE must be able to calculate and apply a multiplier called a "markup" to the manufacturers' prices.

The LCC, LCC subgroup, and markup analyses are essential activities that enable DOE's Building Technologies Program (BTP) to determine the effects of proposed standards on residential and commercial consumers, thus ensuring that BTP fulfills EPCA's requirements and meets its goal of improving the efficiency of buildings and the equipment, components, and systems within them. Through its work prescribing energy efficiency standards, the BTP helps further EERE's mission of strengthening America's energy security, environmental quality, and economic vitality.

6. Project Objective:

This project is designed to satisfy the legislative mandate for DOE to analyze appliance efficiency standards. The LCC analysis and LCC subgroup analysis, and the markups analysis that feeds into them, form part of the basis for DOE to determine whether the standard meets the criterion of being *economically justified*.

7. Project History & Relationships:

This project has been a key component of DOE's energy efficiency standards rulemakings since 1979, and a critical part of the current rulemakings being analyzed by BTP—including the Distribution Transformer standards rulemaking and the Residential Furnaces and Boilers standards rulemaking—since their inception in 2001. Based on the results of the LCC analysis, DOE selects candidate standard levels for a more detailed analysis.

The Markup, LCC, and LCC Subgroup analyses are three of the elements required for performing a full appliance standards analysis. Preceding the Markup, LCC, and LCC Subgroup analyses are the Screening and Engineering analyses. The Screening and Engineering analyses develop the relationship between manufacturer price and appliance efficiency. The Markup analysis transforms manufacturer prices into consumer prices, thereby defining the relationship between consumer price and appliance efficiency. The consumer price and efficiency relationship, along with various other inputs, including electricity prices, energy consumption, appliance lifetime, and discount rate, are used to develop the LCC savings that result from energy conservation standards. The LCC Subgroup analysis uses the same input data as the LCC analysis but is conducted on particular consumer sub-populations to assess whether the impacts of standards affect the sub-population differently than the overall population.

Results from the LCC analysis are fed into the Shipments and National Impact analyses to assess the aggregate impacts at the national level of the net present value (NPV) of total consumer LCC and national energy savings (NES).

8. Technical Approach:

Markups: Based on manufacturer input, this project defines various distribution channels to describe how the regulated appliance or equipment passes from the manufacturer to the consumer. Within a particular distribution channel, the manufactured equipment may pass through several hands before it is ultimately sold to the consumer. For example, in the case of space-conditioning appliances, the manufactured equipment typically passes from a wholesaler to a contractor before being sold to the consumer. In the case of kitchen appliances, the manufactured appliance typically passes only through a large retailer before being sold to the consumer. At each point in the distribution channel, the appliance or equipment is marked up to cover the costs, expenses, and profit of the entity distributing the appliance. For each of the markups, the project differentiates between a baseline markup (a coefficient that relates the manufacturer price of baseline equipment to the wholesale or contractor sales price) and an incremental markup (a coefficient that relates changes in the manufacturer price of baseline equipment to changes in the wholesale or contractor sales price). For some industrial equipment, such as distribution transformers, the efficiency mix of product offerings is so diverse that it is not possible to differentiate between baseline and incremental markups.

Wholesaler, contractor, and retailer markups are calculated, if possible, from firm balance-sheet data, which is provided by either trade associations representing wholesalers, contractors, and retailers or the actual wholesalers, contractors, and retailers. If firm balance-sheet data are not available, U.S. Census data are used instead. U.S. Census data can be put into the same form as the balance-sheet data. The balance sheets break out the components of all costs (i.e., direct costs, expenses, and profit) incurred by firms that distribute the appliance. The key assumptions used to estimate markups using these financial data are:

- The firm balance sheets faithfully represent the various average costs incurred by firms distributing appliances.
- These costs can be divided into two categories: (1) costs that vary in proportion to the manufacturer price of appliances; and (2) costs that do not vary with the manufacturer price of appliances.
- Appliance wholesaler, contractor, and retailer prices vary in proportion to the wholesaler, contractor, and retailer costs included in the balance sheets.

After the markups have been determined, they are used to transform manufacturer costs into the price paid by the consumer for the appliance.

LCC analysis: The LCC is the total consumer expense over the life of the equipment or appliance, including the purchase and installation price, and the operating expense—including operating energy, maintenance, and repair expenditures—discounted over the lifetime of the appliance or equipment. In estimating operating energy costs, this project uses the full range of consumer marginal energy prices, which are the energy prices that correspond to incremental changes in energy use. The LCC analysis also defines a range of energy price forecasts for each fuel used in the economic analyses. A distribution of real discount rates is also used for the calculations.

The LCC analysis is conducted using a spreadsheet model developed in Microsoft Excel. When combined with Crystal Ball (a commercially available software program), the LCC and PBP model generates a Monte Carlo simulation to perform the analysis by incorporating uncertainty and variability considerations. Uncertainty and variability are captured by defining the inputs to the analysis with probability distributions. By defining the inputs in this manner, the project calculates both LCC and LCC savings for various efficiency levels (yielding a distribution of LCC savings, with a mean value and a range) for each product class of the appliance or equipment.

An associated payback period (PBP) analysis also determines impacts on consumers. The PBP is the change in purchase expense due to an increased efficiency standard, divided by the change in annual operating cost that results from the standard. The results are expressed in years. The PBPs are generated with the same spreadsheet model developed for the LCC analysis. Thus, the project calculated PBPs for various efficiency levels (yielding a distribution of PBPs, with a mean value and a range) for each product class of the appliance or equipment.

LCC subgroup analysis: This project also evaluates the impact on identifiable groups of consumers (i.e., subgroups), such as households of different income levels or small businesses, which may be disproportionately affected by a national standard level. It accomplishes this, in part, by analyzing the LCCs and PBPs for those consumers that fall into any identifiable groups and then using the LCC spreadsheet model, which allows for the identification of and sampling of certain sub-groups.

9. Technical Work Plan:

Markups: The project work plan for establishing markups consists of the following elements:

- Identify all of the distribution channels for how the appliance passes from manufacturer to consumer. Appliance manufacturers are typically relied upon for this information.
- Establish the market share of each distribution channel, i.e., the percentage of unit shipments that pass through each distribution channel. Appliance manufacturers are typically relied upon for this information.
- Identify and collect data sources for characterizing the costs, expenses, and profit of each entity in each distribution channel. Data sources include firm balance sheets and U.S. Census data. If available, firm balance sheets are provided by the appropriate trade association.
- Establish how the appliance is marked up to cover the expenses and profit of each entity. If possible, differentiate between baseline and incremental markups. Baseline markups cover all expenses and profit while incremental markups cover only those expenses and profit that change due to an increase in appliance price.
- Determine the consumer price of the appliance by applying the markups of all entities involved in the distribution of the appliance.

LCC analysis: The project work plan for conducting the LCC analysis consists of the following elements:

- Identify all inputs necessary for determining the LCC of appliances and identify the data sources for establishing the inputs. Because the LCC analysis must capture the uncertainty and/or variability of the inputs, most inputs are characterized with probability distributions. In general, the inputs to the LCC analysis consist of the following:
    - *Baseline manufacturer price*: The price charged by the manufacturer to either a wholesaler or retailer for equipment meeting existing minimum efficiency standards. The manufacturer price includes a markup that converts the cost to manufacture into a manufacturer price. Developed by the Engineering analysis.

- *Standard-level manufacturer price increases*: The change in manufacturer price associated with producing equipment at each standard level. Developed by the Engineering analysis.
- *Markups and sales tax*: The markups and sales tax associated with converting the manufacturer price to a consumer price. Developed by the Markup analysis.
- *Installation cost*: The cost to the consumer of installing the equipment. The installation cost represents all costs required to install the equipment other than the marked-up consumer equipment price. The installation cost includes labor, overhead, and any miscellaneous materials and parts. Thus, the total installed cost equals the consumer equipment price plus the installation price. Developed within the LCC analysis. *RS Means Mechanical Cost Data* are typically relied upon as a data source.
- *Equipment energy consumption and power demand*: The equipment energy consumption is the site energy use. The power demand is the maximum power requirement of the equipment (more commonly known as the peak demand) for a specific period of time. Developed within the LCC analysis. Various data sources are used depending on the appliance. DOE/Energy Information Administration (EIA)'s Residential Energy Consumption Survey (RECS), Commercial Building Energy Consumption Survey (CBECS), and Manufacturing Energy Consumption Survey (MECS) are used. Hourly whole-building simulations using such programs as DOE-2 and the Building Loads and System Thermodynamics (BLAST) are sometimes coupled with the EIA survey data to characterize energy use and demand. Reports and/or data detailing metered energy consumption are also used.
- *Equipment efficiency*: The metric used to characterize the efficiency of the appliance. Coupled with the manufacturer price data to provide the relationship between manufacturer price and efficiency. Developed by the Engineering analysis.
- *Energy prices*: Energy prices are the price per kilowatt-hour (kWh) or British Thermal Unit (Btu) paid by each customer for energy. Developed within the LCC analysis. Energy prices are determined through the use of monthly billing data from RECS or CBECS or electric and gas utility tariffs. Marginal energy prices are developed to determine the cost energy savings realized from more-efficient appliances.
- *Energy price trends*: The price trend forecasts energy prices out into the future. Developed within the LCC analysis. EIA's *Annual Energy Outlook* is used to forecast prices into the future.
- *Maintenance costs*: The cost associated with maintaining the operation of the equipment (e.g., cleaning heat exchanger coils, checking refrigerant charge levels). Developed within the LCC analysis. *RS Means Facilities Maintenance & Repair Cost Data* are typically relied upon as a data source.
- *Repair costs*: The cost associated with repairing or replacing components that have failed. Developed within the LCC analysis. Generally a function of consumer appliance price.

    - *Lifetime*: The age at which the equipment is retired from service. Developed within the LCC analysis. Various sources are used to characterize the lifetime.
    - *Discount rate*: The rate at which future expenditures are discounted to establish their present value. Developed within the LCC analysis. For residential appliances, the Federal Reserve Board's *Survey of Consumer Finances* is a primary source of data. For commercial and industrial equipment, the analysis relies on company financial data from various sources (e.g., Bloomberg Financial and Damodaran Online).
- Develop spreadsheet models for calculating the LCC savings and PBPs of proposed standards.
- Generate LCC and PBP results.

LCC Subgroup analysis: the project work plan for conducting the LCC analysis consists of the following elements:
- Identify subgroups to analyze.
- Modify spreadsheet model to analyze only those subgroups of interest.
- Generate LCC and PBP results for each subgroup identified.

10. Technical Problems/Barriers:

Markups: The primary problem is obtaining up-to-date balance-sheet data from either the entities that distribute equipment or the trade associations that represent them to characterize the direct costs, expenses, and profits of firms in the wholesale, contractor, and retail businesses. Without balance-sheet data, data from the U.S. Census Bureau are relied on for the analysis, although some of the Census data are not readily available to the public and must be purchased from the Census. Also, the Census data are typically averaged at the State level and do not necessarily capture the complete variability in costs, expenses, and profit of firms.

LCC analysis: Although there can be difficulty in characterizing all of the inputs to the LCC analysis, the following inputs are the most difficult to precisely characterize:
- *Equipment energy consumption and power demand*: For all appliances, a DOE test procedure is available for establishing the annual energy consumption. However, the algorithms in the test procedure for calculating energy consumption are typically very old and no longer reflect the appliance's energy use. Therefore, the primary problem is to identify other data sources and methods to establish appliance energy consumption.

  For residential products, EIA's Residential Energy Consumption Survey (RECS) is heavily relied on as a data source. RECS does not use metered data to establish end-use energy consumption, but rather, conditional demand analysis (CDA) techniques. Although CDA may provide a representative average energy consumption value over the entire household sample, values for individual household records are highly uncertain. Thus, primary RECS variables, such as climate, square footage, construction, and usage patterns, are often used instead to calculate the annual energy use for individual households. In addition to RECS, other data from research institutions are also utilized.

For commercial products, EIA's Commercial Buildings Energy Consumption Survey (CBECS) is heavily relied on as a data source. But like RECS, metered data are not used to establish end-use energy consumption, but rather a combination of building simulation and CDA techniques. As with RECS, these techniques provide highly uncertain results for individual building records. In addition, the level of detail regarding the type of equipment being used is also uncertain (e.g., rather than specifying the equipment as an air-cooled unitary air conditioner with cooling capacity between 5 tons and 20 tons, the finest level of equipment specificity is "rooftop air conditioner"). As a result, building simulations need to be performed based on the primary variables in CBECS (e.g., climate, building construction, and square footage). Proven simulation tools such as DOE-2 and BLAST are used to perform the simulations. In addition to CBECS, other data from research institutions are also utilized.

For industrial equipment, EIA's Manufacturing Energy Consumption Survey (MECS), although useful, does not provide the detailed end-use data necessary for conducting an LCC analysis. In this case, outside data sources are relied on. In the case of a product like distribution transformers, system load data from individual utilities and the Federal Energy Regulatory Commission are used. Also, proprietary data sources are used. When proprietary data are used, care must be taken when publishing technical documents so as not to violate confidentiality agreements.

- *Energy prices*: Energy prices have been established using the same sources as identified above, e.g., RECS for residential products and CBECS for commercial products. There are two significant problems with these data sources—first and foremost, the availability of the data. In the case of RECS, EIA staff have stated that the monthly bill data (consisting of energy consumption and utility bills) will no longer be made available due to issues of confidentiality. That is, EIA fears that the monthly bill data will compromise the identity of the households or buildings that have participated in the survey. Second, the bill data provided are not complete, i.e., all monthly records for a particular record are not provided and/or there are a limited number of records that actually have bill data. This has been more of a problem with CBECS data. Third, in the case of LCC analyses for commercial products, because the development of marginal prices relies on the hourly performance of the product, the monthly bill data are not disaggregated enough to be useful. For all these reasons, a tariff-based approach must now be utilized for developing energy prices. This is a highly labor intensive process that requires a broad sample of tariffs from a nationally representative set of utilities. Tariffs must be collected, modeled, and applied to the energy consumption and demand data in order to calculate marginal energy prices. Although labor intensive, the approach has been demonstrated to be robust and reflective of current energy prices paid by residential, commercial, and industrial consumers.

- *Energy price trends*: The default energy price trends used in past and current appliance standards rulemakings have been based on the DOE-EIA *Annual Energy Outlook (AEO)'s* Reference Case. Other sensitivities typically used are the *AEO's* High Growth and Low Growth Cases. Although these price trends are DOE's official price forecasts, they have often been criticized as not reflecting near-term expected energy prices. For example, past *AEOs* have significantly underestimated the recent (2000-2002) price volatility in electricity prices. Also, the *AEO's* recent natural gas price forecasts have been shown to be significantly lower than forecasts from *Henry Hub* and U.S. Wellhead futures prices. Thus, the most significant problem with determining energy price trends is to capture the full variability of expected prices given the high sensitivity of the LCC to energy prices.

- *Discount rates*: Discount rates are used to establish the present value of future operating cost savings. Interested parties have extensively debated which discount rate to use. Some stakeholders advocate a high discount rate that reflects the consumer interest rate for purchases on credit cards, while other stakeholders urge the use of a low discount rate that reflects cash purchases or purchases made through low-interest financial vehicles. The significant problem facing the establishment of discount rates is to capture the full breadth of values that are possible. Methods recently used have accomplished this. For residential products, the Federal Reserve Board's *Survey of Consumer Finances* is used to identify the portfolio of debt and equity held by typical consumers. The interest rates associated with this debt and equity are used to characterize the range of discount rates. For commercial and industrial equipment, a method relying on the calculation of the weighted-average cost of capital (WACC) is used. The WACC calculation relies on company financial data from various sources (e.g., Bloomberg Financial and Damodaran Online). Although these techniques have proven to be robust, each new rulemaking requires that all data sources be updated to reflect the current cost of debt and equity to consumers and commercial and industrial customers.

LCC Subgroup analysis: The primary difficulty facing the LCC Subgroup analysis is obtaining the information necessary to clearly define those subgroups that may disproportionately be disadvantaged by an energy conservation standard. Typically, low-income consumers and seniors are considered in the LCC Subgroup analysis for residential products. For commercial and industrial equipment, small businesses (as measured by annual receipts or revenue) are considered. The other difficulty in conducting Subgroup analyses is adequately addressing the "split incentive" issue. This is the case where a home or building is not owner-occupied and, therefore, the renter is not involved with the purchase of the appliance but is billed for the operation of it. Many low-income consumers are renters and, therefore, cannot affect the type of appliance that is used.

11. Status of Milestones:
For the standards rulemakings discussed here—distribution transformers (DT) and residential furnaces and boilers (FB)—a Markup analysis and an LCC analysis were conducted for each product's Advance Notice of Proposed Rulemaking (ANOPR). Both the DT and FB ANOPRs were published on July 29, 2004. Based on DOE's Process Rule, an LCC Subgroup analysis is not conducted until the Notice of Proposed Rulemaking (NOPR) phase of the standards rulemaking.

According to "The Regulatory Plan and the Unified Agenda of Federal Regulatory and Deregulatory Actions" (69 FR 72712-72713) (commonly referred to as the *Regulatory Agenda*), the NOPR for DT and FB are both scheduled to be published in September, 2006. Prior to publishing the NOPRs, the *Regulatory Agenda* calls for Technical Support Documents (TSDs) to be reviewed by the Department by September, 2005. Because TSDs are required to be completed and reviewed by September, 2005, the Markup and LCC analyses must be revised and the LCC Subgroup analysis must be conducted by May, 2005. All three of these analyses have been completed.

Discussed below are the most significant revisions made to the Markup and LCC analyses for DT and FB, as well as which subgroups were analyzed for the LCC Subgroup analyses.

Markups: The Markup analyses for DT and FB were not significantly revised for the NOPR, primarily because of the work done to validate the Markup analysis methodology for commercial unitary air conditioners. A team commissioned by DOE to review certain analytical aspects of the commercial unitary air conditioner rulemaking validated the methodology used to conduct the Markup analysis.

LCC analysis: Both the DT and FB LCC analyses were revised for their respective NOPRs due to comments received from interested parties on their ANOPRs.

- For DT, the most significant revisions were: (1) changes to the manufacturer prices (developed by the Engineering Analysis) and (2) changes in the percentage of customers evaluating the costs and benefits of purchasing efficient transformers.
- For FB, the most significant revision was the update to use data from the 2001 RECS (the ANOPR LCC analysis was based on the 1997 RECS). Other, less-significant changes pertained to: (1) the method for calculating electricity use, and (2) the development of maintenance costs for condensing non-weatherized gas furnaces.

LCC Subgroup analysis: For DT, the subgroups analyzed were rural electric cooperative utilities and municipal utilities. For FB, the subgroups analyzed were low-income consumers and seniors.

12. Efficiency Improvement Metrics:
There are ten product classes of DT that are being analyzed, consisting of thirteen design lines. The ten product classes are divided into classes of liquid-type transformers,

typically used by electric utilities, and dry-type transformers, which are typically used at commercial and industrial building sites. The energy descriptor for DT is *efficiency*, which measures the total energy losses at a design load of 50 percent for liquid-type transformers and 35 percent for dry-type transformers. The cost of achieving higher transformer efficiency varies significantly over the product classes. The purpose of the NES/NPV part of the national impact spreadsheet is to calculate some of the key quantities by which a candidate energy efficiency standard may be evaluated. Two such quantities are national source energy savings and NPV. Source energy is total energy saved (or reduction in losses) by transformers. NPV is a measure of the net benefit to consumers due to an energy-efficiency standard.

There are six product classes of FB that are being analyzed. The six product classes consist of three furnace classes and three boiler classes. The energy descriptor for FB is the *annual fuel utilization efficiency* (AFUE), which takes into account the fuel consumption over the entire year. For the most predominant product class, non-weatherized gas furnaces, the existing minimum efficiency level is 78% AFUE. The analysis for the ANOPR demonstrates that beyond an AFUE of 81%, a majority of consumers will not realize LCC savings. Due to the changes made to the LCC analysis for the NOPR, efficiency levels up through 81% AFUE still result in a majority of consumers realizing LCC savings. In addition, 90% AFUE furnaces now yield small average LCC savings with a majority of consumers either realizing LCC savings or not being significantly impacted by the increase in the efficiency level.

13. Project Output:

Major Accomplishments:

For DT, the major accomplishments are the publication of the Technical Support Document and the Analytical Spreadsheets that accompanied the ANOPR:

- U.S. Department of Energy-Office of Energy Efficiency and Renewable Energy, *Technical Support Document: Energy Efficiency Program for Commercial and Industrial Equipment: Electrical Distribution Transformers*, July, 2004. Washington, DC.
<http://www.eere.energy.gov/buildings/appliance_standards/commercial/dist_trans_tsd_061404.html>
- U.S. Department of Energy-Office of Energy Efficiency and Renewable Energy, ANOPR Analytical Spreadsheets, Life-Cycle Cost Calculations by Design Line, October, 2004. Washington, DC.
<http://www.eere.energy.gov/buildings/appliance_standards/commercial/distribution_transformers_spreadsheets.html>

For FB, the major accomplishments are the publication of the Technical Support Document and the Analytical Spreadsheets that accompanied the ANOPR:

- U.S. Department of Energy-Office of Energy Efficiency and Renewable Energy, *Technical Support Document: Energy Efficiency Program for Consumer Products: Energy Conservation Standards for Residential Furnaces and Boilers*, September, 2004. Washington, DC.
< http://www.eere.energy.gov/buildings/appliance_standards/residential/furnaces_boilers_1113_r.html>

- U.S. Department of Energy-Office of Energy Efficiency and Renewable Energy, Residential Furnaces and Boilers ANOPR Analytical Tools, October, 2004. Washington, DC.
  < http://www.eere.energy.gov/buildings/appliance_standards/residential/furnace_boiler_draft_analysis.html>

Bibliography:

Wong-Parodi, Gabrielle, Lekov, Alex, Dale, Larry. Natural Gas Prices Forecast Comparison-AEO vs. Natural Gas Markets, LBNL-55701

Dale, Larry, Millstein, Dev, Coughlin, Katie, Van Buskirk, Robert, Rosenquist, Gregory, Lekov, Alex, Bhuyan, Sanjib. An Analysis of Price Determination and Markups in the Air-Conditioning and Heating Equipment Industry, LBNL-52791

Lutz, James, Dunham-Whitehead, Camilla, Lekov, Alex, McMahon, James, "Modeling energy consumption of residential furnaces and boilers in U.S. homes", LBNL-53924, 02/01/2004

Biermayer, Peter, Lutz, James, Lekov, Alex, Measurement of airflow in residential furnaces, LBNL-53947, 01/24/2004

Lutz, James, Lekov, Alex, Dunham-Whitehead, Camilla, Chan, Peter, Meyers, Steve, McMahon, James, Life-cycle cost analysis of energy efficiency design options for residential furnaces and boilers, LBNL-53950, 01/20/2004

14. Budget: N/A

15. Principal Project Personnel:

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- *Role in the project*: Principal Investigator
- *Principal areas of research and expertise*: Identify the feasibility and cost of engineering design changes that could increase energy efficiency for more than 20 specific products, analyze scenarios and economic impacts associated with adoption of these technologies, and assess potential impacts on key market actors, including consumers, manufacturers, utility companies, the nation, and the environment.
- *Percentage of time devoted to the project*: 17%
- *Education*: B.S., Chemistry (Providence College); Ph.D., Molecular Biophysics (Florida State University).
- *Relevant professional employment history*: LBNL, Environmental Energy Technologies Division (1978-present) – currently Head of the Energy Analysis Department, Leader of the Energy Efficiency Standards (EES) Group, and Co-chair of the Water Energy Technology Team (WETT) in the Environmental Energy Technology Division.
- *Relevant professional activities and honors*: American Association for the Advancement of Science, International Association for Energy Economics, co-Chair of American Council for an Energy-Efficient Economy (ACEEE) Summer Study on Buildings (2002).
- *Relevant publications not emanating from this project*: More than 50 publications, including:

Rosenquist, Greg, Michael McNeil, Maithili Iyer, Steve, Meyers, and James McMahon. 2004. Energy Efficiency Standards for Residential and Commercial Equipment: Additional Opportunities. Berkeley, CA. Lawrence Berkeley National Laboratory.

McMahon, James, Steve Meyers, Camilla Dunham Whitehead, Peter Chan, Alex Lekov, and James Lutz. 2004. Life-Cycle Cost Analysis of Energy Efficiency Design Options for Residential Furnaces and Boilers. Berkeley, CA. Lawrence Berkeley National Laboratory.

Rosenquist, Greg, Katie Coughlin, Larry Dale, James McMahon, and Steve Meyers. 2004. Life-Cycle Cost and Payback Period Analysis for Commercial Unitary Air Conditioners. Berkeley, CA. Lawrence Berkeley National Laboratory.

Lutz, James, Camilla Dunham Whitehead, Alex Lekov, James McMahon, 2004. Modeling Energy Consumption of Residential Furnaces and Boilers in U.S. Homes. Berkeley, CA. Lawrence Berkeley National Laboratory. 2004. LBNL-53924.

McMahon, James and Stephen Wiel. 2003. Governments Should Implement Energy-Efficiency Standards and Labels - Cautiously. (31). 13. 1403-15. 2003.

McMahon, James. 2003. New Analysis Techniques for Estimating Impacts of Federal Appliance Efficiency Standards. In Proceedings of the 3rd International Conference on Energy Efficiency in Domestic Appliances and Lighting; Turin, Italy, 1-3 October. (Part II). 927-934. 2003.

Dr. Alex Lekov, Lawrence Berkeley National Laboratory (LBNL), 1 Cyclotron Road, MS-90R4000, Berkeley, CA 94720-8136, Tel: 510-486-6849, Fax: 510-486-6996, Email: ABLekov@lbl.gov.

- *Role in the project*: Project Manager, Residential Furnaces and Boilers
- *Principal areas of research and expertise*: Engineering and economic analysis with emphasis on energy calculations, test procedures, markups, life-cycle cost and national impact analysis; project management.
- *Percentage of time devoted to the project*: 49%
- *Education*: MS, Mechanical Engineering (Technical University, Sofia, Bulgaria, 1973), PhD, Mechanical Engineering (Polytechnic University, Prague, Chech Republic, 1981)
- *Relevant professional employment history:* National Renewable Energy Laboratory, researcher (1986-1990); Berkeley Solar Group, mechanical engineer/energy analyst (1991-1992); ADM Associates Inc., mechanical engineer/energy analyst (1992-1994); XENERGY Inc., mechanical engineer/energy analyst (1994-1996); LBNL, Program Manager (1996-present).
- *Relevant professional activities and honors:* Licenses: Professional Mechanical Engineer (P.E.) in California, Association of Energy Engineers Certified Energy Manager, American Gas Association Chartered Industrial Gas Consultant. Other activities: American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE), Member of Technical Committee on Service Water

Heating, Member of ASHRAE SPC 103 Method of Testing for AFUE of Residential Central Furnaces and Boilers.

- *Relevant publications not emanating from this project*: Holder of six patents and author of more than 60 technical articles and reports, including:

Healy, William, James Lutz, Alex Lekov. 2003. “Variability in Energy Factor Test Results for Residential Electric Water Heaters”, HVAC & R Research, vol.9, No 4, October 2003.

Lekov, Alex, James Lutz, Xiaomin Liu, Camilla Dunham-Whitehead, and James McMahon. 2000. “Determining Benefits and Costs of Improved Water Heater Efficiencies” In Proceedings of the 35th Intersociety Energy Conversion Engineering Conference, Las Vegas, NV July 24-28, American Institute of Aeronautics and Astronautics, 2.1046-1052.

Lekov, Alex, Julie Glover, James Lutz. 2000. The LBNL Water Heater Retail Price Database, LBNL-44749, 10/01/2000.

Lekov, Alex, Alexander Penchev, and Genko Dimitrov. 1991. "New Architectural and Construction Decisions Using Passive Solar Systems", Journal of Building Materials, Bulgaria, Vol. X, Number 1.

Subbarao, Kris, Jay Burch, Doug Balcomb, Ed Hancock, and Alex Lekov. 1989. "Short-Term Energy Monitoring STEM-1.1 User Manual", SERI, TR-254-3613, December.

Lekov, Alex, Doug Balcomb, and Norm Weaver. 1988. "Development of an Expert System to Aid in the Design of Passive Solar Buildings", III Conference on Expert System Applications in Buildings, Tucson, AR, U.S.A.

Lekov, Alex and Doug Balcomb. 1987. "Energy Signatures: New Results," proceedings of the 12th International Passive Solar Conference, Portland, OR, U.S.A.

Lekov, Alex, Alexander Stamenov, Plamen Penkov. 1987. "Evaluation of the Efficiency of Air Solar Heater with Integrated Transparent Covering," Journal of Zdravotni Technika a Vzduchotechnika, Czechoslovakia, Number 6.

Lekov, Alex, Stephan Kanev, Plamen Penkov, Nikolai Zeckov. 1986. "Experimental Study of Fluidized Layer as an Absorber of Flat Plate Solar Collector," Sofia Polytechnics, Bulgaria, Vol. XXIII, Number 2.

Lekov, Alex. 1982. "Evaluation of the Efficiency of a Regenerative-type Heat Exchanger," Journal of Zdravotni Technika a Vzduchotechnika, Czechoslovakia, Number 4.

Patents

Lekov, Alex, reg. #40768/April 12,1985, "Air-to-air Heat Exchanger".

Lekov, Alex, etc., reg. #41603/February 05, 1986, "Thermal Storage Material for Regenerative Type Heat Exchangers".

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- *Role in the project*: Project Manager, Residential Furnaces and Boilers

- *Principal areas of research and expertise*: Appliance standards and testing, focusing on furnaces, water heaters, residential hot water distribution systems, and refrigerators
- *Percentage of time devoted to the project*: 33%
- *Education*: B.A. Sociology (Stanford University, 1979); B.S. Engineering Science, (California Polytechnic University, 1986).
- *Relevant professional employment history:* ADM Associates, Energy Engineer (1986-1987); Sun Up Design, Energy Consultant (1987); Berkeley Solar Group, Engineer (1987-1990); LBNL, Staff Research Associate (1990-present).
- *Relevant professional activities and honors:* Professional Licenses: Professional Engineer, Mechanical Engineering (California); General Building Contractor (California). American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE) Standards Committee; Chair of Standards Project Committee 118.2, Method of Testing for Rating Residential Water Heaters; Chair of Technical Committee 6.6, Service Water Heating Research Subcommittee; Voting Member of Technical Committee 6.6. Formerly Chair of Standards Project Committee 118.1, Method of Testing for Rating Commercial Gas, Electric and Oil Service Water Heating Equipment; Chair of the Project Monitoring Subcommittee of Research Project 1172, Metering Residential Hot Water By End Use; and voting member of Standards Project Committee 146P, Method of Testing for Rating Pool and Spa Heaters. Member of the American Society of Mechanical Engineers, the American Society of Plumbing Engineers, the American Solar Energy Society, and the American Water Works Association.
- *Relevant publications not emanating from this project*: More than 30 publications, including:

  Healy, William; Lutz, James D.; Lekov, Alex, *Variability in Energy Factor Test Results for Residential Electric Water Heaters*, LBNL-51665, Vol. 9, No. 4, HVAC&R Research Journal, October 2003.

  ASHRAE/ANSI Standard 118.1-2003, *Method of Testing for Rating Commercial Gas, Electric and Oil Service Water Heating Equipment*, June 2003.

  Lutz J D., Whitehead C D., Lekov A B., Liu X. , and McMahon J.E., *A Monte Carlo Approach to the Calculation of Energy Consumption for Residential Gas-Fired Water Heaters*, ASHRAE Trans., 2000, Vol.106, Part 2, Paper number MN-00-15-03, LBNL-44829

  Lekov A.B., Whitehead C D., Lutz J D., and McMahon J.E., *Cost of Increased Energy Efficiency for Residential Water Heaters*, ASHRAE Trans., 2000, Vol.106, Part 2, Paper number MN-00-15-02, LBNL-44830

  Lutz J D., Lekov A B., and Whitehead C D., *Residential Water Heaters: The Impact of Regulatory Changes*, 51st Annual International Appliance Technical Conference, Lexington, KY, May 2000, LBNL-44831

  Lutz J D., *Demonstrating Economic Justification - Updating Water Heater Efficiency Standards,* Proceedings of the 2000 ACEEE Summer Study on Energy Efficiency in Buildings, Asilomar, CA, August 2000, LBNL-45829

  Chaitkin S.D., Whitehead C D., Van Buskirk R.D., Lutz J D., and McMahon J.E. *Estimating Marginal Residential Energy Prices in the Analysis of*

Proposed Appliance Energy Efficiency Standards, Proceedings of the 2000 ACEEE Summer Study on Energy Efficiency in Buildings, Asilomar, CA, August 2000, LBNL-44230

Lekov A B., Lutz J D., Whitehead C D., and McMahon J.E., *Payback Analysis of Design Options for Residential Water Heaters,* 2000 ACEEE Summer Study on Energy Efficiency in Buildings, Asilomar, CA, August 2000, LBNL-45312

Lekov A B., Lutz J D., Liu X., Whitehead C D., and McMahon J.E., *Determining Benefits and Costs of Improved WH Efficiencies,* 35th Intersociety Energy Conversion Engineering Conference, Las Vegas, NV, July 2000, LBNL-45618

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- *Role in the project*: Project Manager, Distribution Transformers
- *Principal areas of research and expertise*: Economic and engineering analysis of energy efficiency in buildings and equipment, large-scale field instrumentation and data analysis, thermal comfort
- *Percentage of time devoted to the project*: 54%
- *Education*: BA, Mathematics/Economics (Whitman College); MBA, Finance (University of Washington); Licentiate, Building Services Engineering, and PhD, Building Services Engineering (Chalmers University of Technology, Gothenburg Sweden).
- *Relevant professional employment history:* Pacific Northwest National Laboratory, Research Scientist, Program Manager, Group Leader (1975-1998); Chalmers University of Technology, Guest Researcher (1998-2001); Lawrence Berkeley National Laboratory, Program Manager (2001-present).
- *Relevant professional activities and honors:* American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE).
- *Relevant publications not emanating from this project*: Publications include:

Stoops, J. L. 1998. "Managing the Practical Challenges in Large End-Use Metering Projects." For *Improving Electricity Efficiency in Commercial Buildings*. 21-23 September 1998 Amsterdam, The Netherlands.

Stoops, J. L., and M. H. Sherman, 1994. Co-editors - Proceedings of the American Council for an Energy Efficient Economy 1994 Summer Study on Energy Efficiency in Buildings, Volumes 1 - 10. August 23 – September 3, 1994, Pacific Grove, California. American Council for an Energy-Efficient Economy (ACEEE), Washington, D.C.

Halverson, M. A., J. L. Stoops, J. R. Schmelzer, W. D. Chvala, J. M. Keller, and L. Harris. 1994. “Lighting Retrofit Monitoring for the Federal Sector – Strategies and Results at the DOE Forrestal Building.” In Proceedings of the American Council for an Energy Efficient Economy 1994 Summer Study on Energy Efficiency in Buildings, Vol. 2, pp 2.137-2.144. August 23 – September 3, 1994, Pacific Grove, California. American Council for an Energy-Efficient Economy (ACEEE), Washington, D.C.

Stoops, J. L., et al. 1991. "Building Energy Monitoring." Chapter 37 in *1992 HVAC Applications - ASHRAE Handbook*, ed. R. A. Parsons, pp. 37.1-37.14. American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc., Atlanta, Georgia.

Stoops, J. L. 1990. "End-Use Profile Development From Whole Building Data Combined With Intensive Short Term Monitoring." For *Innovative Monitoring Approaches in Buildings*. June 22-26, 1991, Indianapolis, Indiana.

Stoops, J. L., and R. G. Pratt. 1990. "Empirical Data for Uncertainty Reduction." For *ACEEE 1990 Summer Study*. August 26 - September 1, 1990, Pacific Grove, California.

Conner, C. C., J. L. Stoops, and M. A. Halverson. 1990. "The Practical Challenges of Converting End-Use Data Into Information." In *End-Use Load Information and Its Role in DSM*, pp. (session one, projects). July 11-13, 1990, Irvine, California.

Dr. Robert Van Buskirk, Lawrence Berkeley National Laboratory (LBNL), 1 Cyclotron Road, MS-90R4000, Berkeley, CA 94720-8136, Tel: 510-495-2310, Fax: 510-486-6996, Email: RDVanBuskirk@lbl.gov.

- *Role in the project*: Chief Analyst
- *Principal areas of research and expertise*: Planning, development, and production of energy and energy efficiency policy analysis. Development of policy analysis models, software, and spreadsheet tools. Applications include the economic feasibility analysis of appliance, efficiency standards and programs in the U.S. and internationally. Supervision of research in the economics of policy impacts, costs and benefits. Development of integrated economic, meteorological, and air quality models for air quality policy analysis.
- *Percentage of time devoted to the project*: 44%
- *Education*: B.A., Physics & Mathematics (Univ. of California, Berkeley, 1984); M.A., Physics (Harvard University, 1986); Ph.D., Physics (Harvard University, 1991).
- *Relevant professional employment history:* Natural Resources Consulting Engineers, Modeling Specialist (1991-1993); University of Asmara, Eritrea, Assistant Professor/Fulbright Scholar (1993-1996); Eritrea Technical Exchange, System Administrator/Developer (1995-1997); Eritrea Department of Energy, Senior Research Scientist (1995-1997); Calmar Online Communications Ltd., Hong Kong/Beijing, Technical Project Manager (1997-1998); San Jose State University, Adjunct Professor (1997-1999); LBNL, Principal Research Associate (1999-2000); Santa Clara University, Adjunct Professor (2004-present); Department of Meteorology, San Jose State University, Adjunct Professor (2002-present); LBNL, Scientist (2000-present).
- *Relevant professional activities and honors:* Lab Director's Research Development grant: "Evaluation of dyanamic air quality impacts of distributed generation," October 2002; Outstanding Performance Award, Lawrence Berkeley National Laboratory, October 2001; J. William Fulbright Lecturer Award, September 1993 - September 1994.

- *Relevant publications not emanating from this project*:

  Dale, Larry, Dey Millstein, Katie Coughlin, Robert Van Buskirk, Greg Rosenquist, Alex Lekov, Sanjib Bhuyan. 2004. "An Analysis of Price Determination and Markups in the Air-Conditioning and Heating Equipment Industry." LBNL-5279.

  Coughlin, Katie and Robert Van Buskirk. 2002. Efficiency policy analysis with temporally and regionally varying energy costs. IEECB-RL5 Conference, May 28-31, 2002, Nice, FRANCE.

  Van Buskirk, Robert and Katie Coughlin. 2002. Measuring National and Regional Trends and Transformations in Electricity Use, Efficiency, and Conservation. IEECB-RL5 Conference, May 28-31, 2002, Nice, FRANCE.

  Rosenquist, Greg, P. Chan, A. Lekov, J. McMahon, and R. Van Buskirk. 2002. "Consumer Life-Cycle Impacts of Energy Efficiency Standards for Residential-Type Central Air Conditioners and Heat Pumps," ASHRAE Winter Meeting, January 12-16, 2002, Atlantic City, New Jersey, U.S.A.

  Coughlin, Katie and Robert Van Buskirk. 2001. "Boom/Bust Cycles in Electricity Infrastructure Development," EPRI 13-th Forecasting Symposium: Price and Load Forecasting in Volatile Energy Markets, November 13-15, 2001, Nashville, TN.

  Van Buskirk, R., K. Coughlin, and E. Rendek. 2001. "Modeling Price-Load Relationships in Electricity Markets," EPRI 13-th Forecasting Symposium: Price and Load Forecasting in Volatile Energy Markets, November 13-15, 2001, Nashville, TN.

  Van Buskirk, Robert. 2000. "Econometric modeling of the effects of energy efficiency standards on appliance shipments," In Proceedings 2000 ACEEE Summer Study on Energy Efficiency in Buildings, 9.371, American Council for an Energy-Efficient Economy, Washington D.C.

  Chaitkin, S., G. Rosenquist, C. Dunham Whitehead, R. Van Buskirk, and J.E. McMahon. 2000. Estimating and applying marginal energy prices in the analysis of proposed appliance energy efficiency standards in the residential sector, submitted to the 2000 ACEEE Summer Study on Energy Efficiency in Buildings.

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- *Role in the project*: Economist/scientist: Estimate distribution markups, discount rates, and employment impacts, and research tax impacts on LCC results, appropriate LCC procedures, and price impacts of efficiency standards.
- *Principal areas of research and expertise*: Water energy economics, energy economics, and energy market and pricing.
- *Percentage of time devoted to the project*: 6%

- *Education*: Ph.D., Agricultural Economics (University of Hawaii, 1990); M.S., Agricultural Economics (University of California, Davis); B.A., Economics (University of California, Davis).
- *Relevant professional employment history:* Forest and Range Experiment Station, Economist (1979-1982); East West Center, Fellow (1983-1987); University of Santa Clara, Professor, Consultant (1995-2002); LBNL, Economist/Scientist (2001-present).
- *Relevant publications not emanating from this project*:

  Hayhoe, Katharine, Larry Dale, et al. 2004. "Emissions Pathways, Climate Change, and Impacts on California," in *Proceedings of the National Academy of Sciences*. August 16, 2004.

  Dale, Larry, C.D. Whitehead, and N. Williams. 2003. "Trends in the Adoption of Residential Water Meters in California" in *Advances in Water Supply Management.* Cedo Maksimovic and David Butler. September 2003, Palkema Publishers.

  Paper presented at the Computer and Control in the Water Industry (CCWI) Conference in London, August 2003.

  Dale, Larry, K.Coughlin, G.Rosenquist, A.Lekov and D. Millstein. 2003. "Markups for Equipment Price Determination." June 2003. LBNL-52791.

  Sathaye, Jayant, Willy Makundi and Larry Dale. 2003. Estimating Forestry Climate Mitigation Potential and Costs: A Partial Equilibrium Approach and Indonesia Case Study. Presented at the Energy Modeling Forum (EMF 21). March 2003. *Energy Journal*. Accepted 2005.

  Dale, Larry, Camilla Dunham Whitehead, and Andre Fargeix. 2003. "Electricity Price and Southern California's Water Supply Options." *Resources, Conservation and Recycling*, March 2004.

  Dale, Larry, Camille Antinori, Michael McNeil and Jim McMahon. 2003. "Retrospective evaluation of declining prices for energy efficiency appliances." In *Energy Efficiency in Domestic Appliances and Lighting (EEDAL'03) conference proceedings*. September 2003.

  Dale, Larry and Michael Roberts. 2005. "Discount rates applied to energy conservation projects." June 2005. LBNL-50442.

  Dale, Larry. 2003. "The Benefits of Appliance Efficiency Standards to Landlords and Tenants." Draft work. June 2003. LBNL – 53070.

  Rosenquist, Greg, Katie Coughlin, Larry Dale, James McMahon and Steve Meyers. 2004. Life-cycle Cost and Payback Period Analysis for Commercial Unitary Air Conditioners. March 2004. LBNL-54244.

16. Other Information Sources:

More information on the project can be found on the following websites:

- http://www.eere.energy.gov/buildings/appliance_standards/residential/furnaces_boilers.html
- http://www.eere.energy.gov/buildings/appliance_standards/commercial/distribution_transformers.html
- http://eappc76.lbl.gov/tmacal/ees.cfm

PROJECT DESCRIPTION

1. Project Title: U.S. DOE Energy Conservation Standards: Shipments and National Impact Analyses

2. Principal investigator:

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3. Other Participating Organizations: Project Managers, U.S. Department of Energy

4. Project:

Distribution Transformers:

1. Schedule
    a. Initiation Date: October 1, 2000
    b. Dates of Intermediate Phase Completions or Go/No-Go Points: Advance Notice of Proposed Rulemaking (ANOPR) published July 29, 2004; ANOPR Public Meeting on September 28, 2004; ANOPR Comment Period ended November 9, 2004.
    c. Original Expected Completion Date: "The Regulatory Plan and the Unified Agenda of Federal Regulatory and Deregulatory Actions" (69 FR 72712-72713) (commonly referred to as the *Regulatory Agenda*) calls for the Notice of Proposed Rulemaking (NOPR) to be published in September, 2006. It is scheduled to be published in September, 2006. Prior to publishing the NOPR, the *Regulatory Agenda* calls for a Technical Support Document (TSD) to be reviewed by the Department by September, 2005.
2. Funding Status: Appliance Standards projects are currently awarded on a non-competitive basis.
3. Project/technology maturity – Analysis

    The focus of the Distribution Transformers standards rulemaking is to publish a Final Rule that promulgates energy conservation standards for this product. As part of the rulemaking, in-depth technical analyses are conducted and published, detailing the impacts of potential efficiency standards on production costs (i.e., cost to manufacture), consumer life-cycle cost, national energy savings, and manufacturer profitability, air-borne emissions, and national employment.

Residential Furnaces and Boilers:

1. Schedule
    a. Initiation Date: October 1, 2000
    b. Dates of Intermediate Phase Completions or Go/No-Go Points: Advance Notice of Proposed Rulemaking (ANOPR) published July 29, 2004; ANOPR Public Meeting on September 29, 2004; ANOPR Comment Period ended November 10, 2004.
    c. Original Expected Completion Date: "The Regulatory Plan and the Unified Agenda of Federal Regulatory and Deregulatory Actions" (69 FR 72712-72713) (commonly referred to as the *Regulatory Agenda*) calls for the Notice of Proposed Rulemaking (NOPR) to be published in September, 2006. It is scheduled to be published in September, 2006. Prior to publishing the NOPR, the *Regulatory Agenda* calls for a Technical Support Document (TSD) to be reviewed by the Department by September, 2005.
2. Funding Status: Appliance Standards projects are currently awarded on a non-competitive basis
3. Project/technology maturity – Analysis
    The focus of the Residential Furnaces and Boilers standards rulemaking is to publish a Final Rule that promulgates energy conservation standards for this product. As part of the rulemaking, in-depth technical analyses are conducted and published, detailing the impacts of potential efficiency standards on production costs (i.e., cost to manufacture), consumer life-cycle cost, national energy savings, and manufacturer profitability, air-borne emissions, and national employment.

5. Statement of Problem:

The Energy Policy and Conservation Act (EPCA) specifies that any new or amended energy conservation standard for consumer products shall be designed to achieve the maximum improvement in energy that is technologically feasible and economically justified. Furthermore, when DOE is determining the economic justification for its standards, EPCA directs it to consider a number of different factors, including the total projected amount of energy savings likely to result from the imposition of a standard. To estimate the total energy savings resulting from a standard, the Department must determine the shipments of the product in question, calculate the difference between the base case efficiency and the efficiency of each standards case, and forecast the effects of the standard on energy consumption.

The national impacts and shipments analyses are essential activities that enable DOE's Building Technologies Program (BTP) to determine the effects of proposed standards on the Nation, ensuring that BTP fulfills EPCA's requirements and meets its goal of improving the efficiency of buildings and the equipment, components, and systems within them. These analyses also directly address EERE's mission of strengthening America's energy security and economic vitality, since ensuring a reduction in the overall demand for energy will likely reduce the Nation's reliance on foreign sources of energy. Reduced demand also is likely to improve the reliability of the electricity system, particularly during peak-load periods.

6. Project Objectives:

This project is designed to satisfy the legislative mandate for DOE to analyze appliance efficiency standards. The national impact analysis, and the shipments analysis on which it is based, address the legislative criteria that a standard must provide the nation with *significant energy savings* and be *economically justified*.

7. Project History & Relationships:

This project has been a key component of DOE's energy efficiency standards rulemakings since 1979, and a critical part of the current rulemakings being analyzed by BTP—including the Distribution Transformer standards rulemaking and the Residential Furnaces and Boilers standards rulemaking—since their inception in 2001. Based on the results of the National Impact analysis, DOE selects candidate standard levels for a more detailed analysis.

The Shipments and National Impact analyses are two of the elements required for performing a full appliance standards analysis. Preceding the Shipments and National Impact analyses is the Life-Cycle Cost (LCC) analysis. The LCC analysis develops the relationship between consumer equipment price and equipment efficiency. Using this relationship, along with various other inputs—including energy prices, energy consumption, appliance lifetime, and discount rate—the LCC savings that result from energy conservation standards are developed. Because most of the inputs to the LCC analysis are characterized with probability distributions to capture the uncertainty and variability inherent in these inputs, a distribution of LCC results is generated that depicts not only the average LCC savings from an efficiency standard but also the percent of consumers that would realize LCC savings from the standard. Most of the inputs to the Shipments and National Impact analyses are developed by the LCC analysis, including the consumer equipment price, annual energy consumption, and energy price. However, because the Shipments and National Impact analyses are conducted at the national level, inputs to the analysis are characterized with single-point values, as opposed to the probability distributions used in the LCC analysis. The Shipments and National Impact analyses determine the national energy savings and national consumer net present value (NPV) that result from energy conservation standards. The national NPV of an efficiency standard is the difference between the sum of national consumer equipment costs and operating costs in the base case (i.e., the case without updated efficiency standards) and the sum of national total installed costs and operating costs in the standards case. An NPV greater than zero shows net savings (i.e., the energy efficiency standard reduces consumer expenditures in the standards case relative to the base case).

Results from the Shipments analysis are fed into the Manufacturer Impact analysis. Results from the National Impact analysis are fed into the Utility Impact analysis, Environmental Assessment, and Employment Impact analysis. The Regulatory Impact analysis is conducted with the modeling tools used to develop the Shipments and National Impact analyses.

8. Technical Approach:

Shipments analysis: Annual forecasts of national energy savings and national economic costs resulting from a potential standard start with an estimate of the national sales (shipments) of the appliance or product and their efficiencies. An accounting spreadsheet model is used to prepare shipment scenarios for the base case (i.e., the case without updated efficiency standards) and the various standard cases considered for the appliance being analyzed. The spreadsheet model is organized into three classes of elements: stocks, events, and decisions. "Stocks" are the inventory of installed appliances. Historical values for the overall appliance stock are based on saturation data (i.e., the percentage of households or buildings that use the appliance). The model divides appliance stocks into ownership categories, and assigns appliance units to age categories. "Events" are things that happen to stocks independent of economic conditions, i.e., breakdowns requiring repair or replacement. "Decisions" are consumer purchase decisions that are reactions to market conditions, e.g., whether to repair or replace equipment, or to purchase an appliance for a household or building which does not have one. Households or buildings without an appliance are typically based on new construction starts, although existing housing of building stocks without the appliance are included as well. The model characterizes consumer purchase decisions by market segments. The model uses decision trees 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 household or business income level. Historical shipments are used to calibrate the spreadsheet model.

National Impact analysis: The National Impact analysis determines the national energy savings and national consumer NPV of energy efficiency standards. National energy savings are determined by multiplying the number or stock of appliances by vintage (as determined by the Shipments analysis) by the per-unit energy consumption. Per-unit energy consumption is a function of vintage (where vintage is the age of the appliance) and is provided by the LCC analysis. National energy savings are determined by subtracting energy use under a standards scenario from energy use in a base case scenario. Energy use is reduced when a piece of equipment is purchased under a standards scenario instead of a less efficient piece of equipment under the base case scenario.

The NPV is the sum over time of discounted net savings to equipment consumers as a result of new standards. The national NPV of an efficiency standard is the difference between the sum of national equipment consumer costs and operating costs in the base case and the sum of national consumer equipment and operating costs in the standards case. Annual net savings are calculated as the difference between total operating cost savings and increases in total consumer equipment costs. Operating and equipment costs are based on average per-unit values provided by the LCC analysis. Future costs and savings are discounted to the present with a discount factor. The discount factor is calculated from the discount rate and the number of years between a present year (i.e., the year to which the sum is discounted) and the year in which the costs and savings occur. The NPV is then calculated as the difference between the present value of operating cost savings and the present value of increased total installed costs. An NPV greater than zero shows net savings (i.e., the energy efficiency standard reduces consumer expenditures in the standards case relative to the base case). An NPV that is less than zero indicates that the energy efficiency standard incurs net costs.

This project uses an MS Excel spreadsheet model—the national energy savings (NES) spreadsheet—to calculate the energy savings and the national economic costs and savings from new standards. For each candidate standard level identified in the LCC analysis, the spreadsheet model calculates the total source energy savings and net present value (NPV).

9. Technical Work Plan:

Shipments analysis: The project work plan for conducting the Shipments analysis consists of the following elements:

- Identify market segments in which the appliance is used (e.g., new buildings, existing buildings with broken appliances, and existing buildings acquiring the appliance for the first time). Market segments are typically developed through a market assessment. Various Federal government data sources are relied on to develop this information (e.g., DOE-Energy Information Administration (EIA)'s Residential Energy Consumption Survey (RECS), Commercial Building Energy Consumption Survey (CBECS), and Manufacturing Energy Consumption Survey (MECS)).
- Identify categories of stock appliances (e.g., appliances that have received normal maintenance repairs and appliances that have had their lives extended through additional repairs). This information is typically obtained through discussions with representatives from the industry being regulated.
- Develop mathematical model to forecast shipments that accounts for the following:
    - Broken equipment,
    - New equipment,
    - Demolitions, and
    - Probability of purchase and probability of repair equations as a function of consumer appliance price, operating cost savings, purchaser income, and where applicable, fuel and/or equipment switching (i.e., a switch to an alternative appliance that provides the same consumer utility).
- Collect the following data required to forecast shipments to the identified market segments:
    - Forecasted annual new construction starts (data provided by EIA's National Energy Modeling System (NEMS)),
    - Historical existing stock of households or floor space (data provided by EIA's NEMS and the U.S. Census Bureau), and
    - Historical demolition rates to estimate demolished households or floor space (data provided by EIA's NEMS and the U.S. Census Bureau).
- Collect the following data required for establishing the probability of purchase and probability of repair equations:
    - Per-unit consumer appliance price as a function of efficiency (developed by the LCC analysis),
    - Per-unit operating cost savings as a function of efficiency (developed by the LCC analysis), and
    - Purchaser income (data provided by U.S. Census Bureau and/or private institutions (e.g., Building Owners and Managers Association)).
- Collect the following data for calibrating the Shipments model:
    - Historical appliance shipments (provided by trade associations and/or U.S. Census Bureau),

- Historical market saturation data (provided by EIA in combination with U.S. Census Bureau), and
- Retirement function for the appliance lifetime (provided through various sources).

- Develop the spreadsheet accounting model for forecasting shipments using the above mathematical models, equations, and data.
- Generate shipments forecasts for the base case and various standards cases.

National Impact analysis: The project work plan for conducting the National Impact analysis consists of the following elements:

- Identify and collect data for purposes of calculating national energy savings, including:
  - Per-unit annual energy consumption as a function of efficiency. Developed by the LCC analysis.
  - Annual forecasted shipments. Developed by the Shipments analysis.
  - Annual historical and forecasted appliance stock. Developed by the Shipments analysis.
  - Site-to-source conversion factors for converting energy savings at the site to source or primary energy savings. Marginal conversion factors corresponding to those power plants displaced by appliance efficiency standards are used to develop source energy savings. Marginal conversion factors are generated by DOE-EIA's NEMS.
- Develop equations and method for calculating annual national energy savings from above inputs.
- Identify and collect data for purposes of calculating national consumer NPV, including:
  - Per-unit consumer appliance price as a function of efficiency. Developed by the LCC analysis.
  - Per-unit annual operating cost savings as a function of efficiency. Consists of per-unit annual energy costs, repair costs, and maintenance costs. Per-unit annual energy costs are developed from per-unit annual energy consumption and weighted-average energy prices developed by the LCC analysis. Repair and maintenance costs are also developed by the LCC analysis.
  - Energy price trends to forecast future energy costs. Trends are based on data from EIA's most recent *Annual Energy Outlook*.
  - Discount factors that are a function of discount rate and the present year. Discount rates for the calculation of the NPV are different than those developed for the LCC analysis. Discount rates of 3 percent and 7 percent real are used based on guidelines from the Office of Management and Budget.
- Develop equations and method for calculating the present value of consumer appliance costs and the present value of operating cost savings.
- Develop the NES spreadsheet accounting model for calculating annual national energy savings and annual NPV using the above data and methods.
- Generate cumulative national energy savings and NPV for the various standards cases.

10. Technical Problems/Barriers:

There are two primary problems in conducting the Shipments and National Impact analyses:

(1) obtaining historical shipments data disaggregated both by product class and efficiency, and

(2) developing probability-of-purchase and probability-of-repair equations, especially if fuel and/or equipment switching is to be accounted for.

With regard to the first problem, obtaining disaggregated historical shipments data, typically the trade associations representing the manufacturers whose appliance is being regulated provide such data. Because inputs into both the Shipments and National Impact analyses are at the product class level, shipments must be broken down to the product class level as well in order to develop the aggregate impacts at the national level. However, often the trade associations either do not compile such data or are unable to provide the data due to issues of confidentiality. If disaggregated shipments data by product class are not available, a market assessment usually is conducted that allows for good approximations of annual shipments by product class. Also, the U.S. Census Bureau can sometimes be relied on to provide shipments data by product class. Disaggregated shipments data by efficiency are necessary to properly forecast efficiency trends into the future. If disaggregated shipments data by efficiency are not provided, annual historical shipment weighted-average efficiency data are typically available. In addition, distributions of appliance models by efficiency can be used as a proxy for the disaggregated efficiency data. In combination with the shipment-weighted efficiency data, good approximations of annual shipments broken down into efficiency bins can be made.

The second problem pertains to the difficulty in developing the probability-of-purchase and probability-of-repair equations. As described above, both equations are a function of consumer appliance price, operating cost savings, and purchaser income. To develop these equations, the sensitivity (commonly referred to as the elasticity) of consumer purchase or repair to the above three variables must be developed. Elasticities specific to a given appliance are often difficult to obtain, although economic literature provides a range of reasonable values. The coefficients to the probability of purchase and repair equations are developed based on calibrations to historical market share and shipments data. Generally, the calibrated equations yield results that are reasonable. For example, due to the increase in purchase price of more efficient equipment, shipments forecasts under a standards case are usually lower than under the base case. For some appliances, fuel and/or equipment switching is an issue. Such is the case with residential gas furnaces, since some standard levels may greatly increase the consumer price, causing some consumers to switch to electric heating (either heat pumps or resistance heating). In these cases, the probability of purchase and repair equations must also account for this factor. Often, there are few data indicating the sensitivity of purchase or repair to fuel and/or equipment switching. Thus, any equations developed must be thoroughly vetted to stakeholders participating in the standards rulemaking.

11. Status of Milestones:
For the standards rulemakings discussed here—distribution transformers (DT) and residential furnaces and boilers (FB)—Shipments and National Impact analyses were conducted for each product's Advance Notice of Proposed Rulemaking (ANOPR). Both the DT and FB ANOPRs were published on July 29, 2004.

According to the *Regulatory Agenda*, the NOPRs for DT and FB are both scheduled to be published in September, 2006. Prior to publishing the NOPRs, the *Regulatory Agenda* calls for TSDs to be reviewed by the Department by September, 2005. Because TSDs are required to be completed and reviewed by September, 2005, the Shipments and National Impact analyses must be revised by May, 2005. Both of these analyses have been completed.

Revisions were made to the LCC analyses for both DT and FB. Since many of the inputs to the Shipments and National Impact analyses are developed by the LCC analysis, these analyses were revised for the NOPR for both DT and FB. In addition, all forecasts were updated to use the most recent data from EIA's NEMS and *Annual Energy Outlook*.

12. Efficiency Improvement Metrics:
There are ten product classes of DT that are being analyzed, consisting of thirteen design lines. The ten product classes are divided into classes of liquid-type transformers, typically used by electric utilities, and dry-type transformers, which are typically used at commercial and industrial building sites. The energy descriptor for DT is *efficiency*, which measures the total energy losses at a design load of 50 percent for liquid-type transformers and 35 percent for dry-type transformers. The cost of achieving higher transformer efficiency varies significantly over the product classes. The purpose of the NES/NPV part of the national impact spreadsheet is to calculate some of the key quantities by which a candidate energy efficiency standard may be evaluated. Two such quantities are national source energy savings and NPV. Source energy is total energy saved (or reduction in losses) by transformers. NPV is a measure of the net benefit to consumers due to an energy-efficiency standard.

There are six product classes of FB that are being analyzed. The six product classes consist of three furnace classes and three boiler classes. The energy descriptor for FB is the *annual fuel utilization efficiency* (AFUE), which takes into account the fuel consumption over the entire year. For the most predominant product class, non-weatherized gas furnaces, the existing minimum efficiency level is 78% AFUE. The analysis for the ANOPR demonstrated that for non-weatherized gas furnaces, an 81% AFUE standard would yield an estimated 1.1 quads of cumulative energy savings while providing $0.75 billion in cumulative consumer NPV at a 7 percent real discount rate. The changes made to the National Impact analysis as described above for the NOPR lowered the cumulative energy savings to 0.4 quads for non-weatherized gas furnaces while providing no cumulative consumer NPV.

13. Project Output:

Major Accomplishments:

For DT, the major accomplishments are the publication of the Technical Support Document and the Analytical Spreadsheets that accompanied the ANOPR:

- U.S. Department of Energy-Office of Energy Efficiency and Renewable Energy, *Technical Support Document: Energy Efficiency Program for Commercial and Industrial Equipment: Electrical Distribution Transformers*, July, 2004. Washington, DC. <http://www.eere.energy.gov/buildings/appliance_standards/commercial/dist_trans_tsd_061404.html>
- U.S. Department of Energy-Office of Energy Efficiency and Renewable Energy, ANOPR Analytical Spreadsheets, Life-Cycle Cost Calculations by Design Line, October, 2004. Washington, DC. <http://www.eere.energy.gov/buildings/appliance_standards/commercial/distribution_transformers_spreadsheets.html>

For FB, the major accomplishments are the publication of the Technical Support Document and the Analytical Spreadsheets that accompanied the ANOPR:

- U.S. Department of Energy-Office of Energy Efficiency and Renewable Energy, *Technical Support Document: Energy Efficiency Program for Consumer Products: Energy Conservation Standards for Residential Furnaces and Boilers*, September, 2004. Washington, DC. < http://www.eere.energy.gov/buildings/appliance_standards/residential/furnaces_boilers_1113_r.html>
- U.S. Department of Energy-Office of Energy Efficiency and Renewable Energy, Residential Furnaces and Boilers ANOPR Analytical Tools, October, 2004. Washington, DC. < http://www.eere.energy.gov/buildings/appliance_standards/residential/furnace_boiler_draft_analysis.html>

Bibliography:

Wong-Parodi, Gabrielle, Lekov, Alex, Dale, Larry. Natural Gas Prices Forecast Comparison-AEO vs. Natural Gas Markets, LBNL-55701

Dale, Larry, Millstein, Dev, Coughlin, Katie, Van Buskirk, Robert, Rosenquist, Gregory, Lekov, Alex, Bhuyan, Sanjib. An Analysis of Price Determination and Markups in the Air-Conditioning and Heating Equipment Industry, LBNL-52791

Lutz, James, Dunham-Whitehead, Camilla, Lekov, Alex, McMahon, James, "Modeling energy consumption of residential furnaces and boilers in U.S. homes", LBNL-53924, 02/01/2004

Biermayer, Peter, Lutz, James, Lekov, Alex, Measurement of airflow in residential furnaces, LBNL-53947, 01/24/2004

Lutz, James, Lekov, Alex, Dunham-Whitehead, Camilla, Chan, Peter, Meyers, Steve, McMahon, James, Life-cycle cost analysis of energy efficiency design options for residential furnaces and boilers, LBNL-53950, 01/20/2004

14. Budget: N/A

15. Principal Project Personnel:

Dr. James McMahon, Lawrence Berkeley National Laboratory (LBNL), 1 Cyclotron Road, MS-90R4000, Berkeley, CA 94720-8136, Tel: 510-486-6049, Fax: 510-486-6996, Email: JEMcMahon@lbl.gov.

- *Role in the project*: Principal Investigator
- *Principal areas of research and expertise*: Identify the feasibility and cost of engineering design changes that could increase energy efficiency for more than 20 specific products, analyze scenarios and economic impacts associated with adoption of these technologies, and assess potential impacts on key market actors, including consumers, manufacturers, utility companies, the nation, and the environment.
- *Percentage of time devoted to the project*: 9%
- *Education*: B.S., Chemistry (Providence College); Ph.D., Molecular Biophysics (Florida State University).
- *Relevant professional employment history*: LBNL, Environmental Energy Technologies Division (1978-present) – currently Head of the Energy Analysis Department, Leader of the Energy Efficiency Standards (EES) Group, and Co-chair of the Water Energy Technology Team (WETT) in the Environmental Energy Technology Division.
- *Relevant professional activities and honors*: American Association for the Advancement of Science, International Association for Energy Economics, co-Chair of American Council for an Energy-Efficient Economy (ACEEE) Summer Study on Buildings (2002).
- *Relevant publications not emanating from this project*: More than 50 publications, including:

  Rosenquist, Greg, Michael McNeil, Maithili Iyer, Steve, Meyers, and James McMahon. 2004. Energy Efficiency Standards for Residential and Commercial Equipment: Additional Opportunities. Berkeley, CA. Lawrence Berkeley National Laboratory.

  McMahon, James, Steve Meyers, Camilla Dunham Whitehead, Peter Chan, Alex Lekov, and James Lutz. 2004. Life-Cycle Cost Analysis of Energy Efficiency Design Options for Residential Furnaces and Boilers. Berkeley, CA. Lawrence Berkeley National Laboratory.

  Rosenquist, Greg, Katie Coughlin, Larry Dale, James McMahon, and Steve Meyers. 2004. Life-Cycle Cost and Payback Period Analysis for Commercial Unitary Air Conditioners. Berkeley, CA. Lawrence Berkeley National Laboratory.

  Lutz, James, Camilla Dunham Whitehead, Alex Lekov, James McMahon, 2004. Modeling Energy Consumption of Residential Furnaces and Boilers in U.S. Homes. Berkeley, CA. Lawrence Berkeley National Laboratory. 2004. LBNL-53924.

  McMahon, James and Stephen Wiel. 2003. Governments Should Implement Energy-Efficiency Standards and Labels - Cautiously. (31). 13. 1403-15. 2003.

McMahon, James. 2003. New Analysis Techniques for Estimating Impacts of Federal Appliance Efficiency Standards. In Proceedings of the 3rd International Conference on Energy Efficiency in Domestic Appliances and Lighting; Turin, Italy, 1-3 October. (Part II). 927-934. 2003.

Dr. Alex Lekov, Lawrence Berkeley National Laboratory (LBNL), 1 Cyclotron Road, MS-90R4000, Berkeley, CA 94720-8136, Tel: 510-486-6849, Fax: 510-486-6996, Email: ABLekov@lbl.gov.

- *Role in the project*: Project Manager, Residential Furnaces and Boilers
- *Principal areas of research and expertise*: Engineering and economic analysis with emphasis on energy calculations, test procedures, markups, life-cycle cost and national impact analysis; project management.
- *Percentage of time devoted to the project*: 29%
- *Education*: MS, Mechanical Engineering (Technical University, Sofia, Bulgaria, 1973), PhD, Mechanical Engineering (Polytechnic University, Prague, Chech Republic, 1981)
- *Relevant professional employment history:* National Renewable Energy Laboratory, researcher (1986-1990); Berkeley Solar Group, mechanical engineer/energy analyst (1991-1992); ADM Associates Inc., mechanical engineer/energy analyst (1992-1994); XENERGY Inc., mechanical engineer/energy analyst (1994-1996); LBNL, Program Manager (1996-present).
- *Relevant professional activities and honors:* Licenses: Professional Mechanical Engineer (P.E.) in California, Association of Energy Engineers Certified Energy Manager, American Gas Association Chartered Industrial Gas Consultant. Other activities: American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE), Member of Technical Committee on Service Water Heating, Member of ASHRAE SPC 103 Method of Testing for AFUE of Residential Central Furnaces and Boilers.
- *Relevant publications not emanating from this project*: Holder of six patents and author of more than 60 technical articles and reports, including:

Healy, William, James Lutz, Alex Lekov. 2003. “Variability in Energy Factor Test Results for Residential Electric Water Heaters”, HVAC & R Research, vol.9, No 4, October 2003.

Lekov, Alex, James Lutz, Xiaomin Liu, Camilla Dunham-Whitehead, and James McMahon. 2000. “Determining Benefits and Costs of Improved Water Heater Efficiencies” In Proceedings of the 35th Intersociety Energy Conversion Engineering Conference, Las Vegas, NV July 24-28, American Institute of Aeronautics and Astronautics, 2.1046-1052.

Lekov, Alex, Julie Glover, James Lutz. 2000. The LBNL Water Heater Retail Price Database, LBNL-44749, 10/01/2000.

Lekov, Alex, Alexander Penchev, and Genko Dimitrov. 1991. "New Architectural and Construction Decisions Using Passive Solar Systems", Journal of Building Materials, Bulgaria, Vol. X, Number 1.

Subbarao, Kris, Jay Burch, Doug Balcomb, Ed Hancock, and Alex Lekov. 1989. "Short-Term Energy Monitoring STEM-1.1 User Manual", SERI, TR-254-3613, December.

Lekov, Alex, Doug Balcomb, and Norm Weaver. 1988. "Development of an Expert System to Aid in the Design of Passive Solar Buildings", III Conference on Expert System Applications in Buildings, Tucson, AR, U.S.A.

Lekov, Alex and Doug Balcomb. 1987. "Energy Signatures: New Results," proceedings of the 12th International Passive Solar Conference, Portland, OR, U.S.A.

Lekov, Alex, Alexander Stamenov, Plamen Penkov. 1987. "Evaluation of the Efficiency of Air Solar Heater with Integrated Transparent Covering," Journal of Zdravotni Technika a Vzduchotechnika, Czechoslovakia, Number 6.

Lekov, Alex, Stephan Kanev, Plamen Penkov, Nikolai Zeckov. 1986. "Experimental Study of Fluidized Layer as an Absorber of Flat Plate Solar Collector," Sofia Polytechnics, Bulgaria, Vol. XXIII, Number 2.

Lekov, Alex. 1982. "Evaluation of the Efficiency of a Regenerative-type Heat Exchanger," Journal of Zdravotni Technika a Vzduchotechnika, Czechoslovakia, Number 4.

<u>Patents</u>

Lekov, Alex, reg. #40768/April 12,1985, "Air-to-air Heat Exchanger".

Lekov, Alex, etc., reg. #41603/February 05, 1986, "Thermal Storage Material for Regenerative Type Heat Exchangers".

James Lutz, Lawrence Berkeley National Laboratory (LBNL), 1 Cyclotron Road, MS-90R4000, Berkeley, CA 94720-8136, Tel: 510-486-7302, Fax: 510-486-6996, Email: JDLutz@lbl.gov.

- *Role in the project*: Project Manager, Residential Furnaces and Boilers
- *Principal areas of research and expertise*: Appliance standards and testing, focusing on furnaces, water heaters, residential hot water distribution systems, and refrigerators
- *Percentage of time devoted to the project*: 19%
- *Education*: B.A. Sociology (Stanford University, 1979); B.S. Engineering Science, (California Polytechnic University, 1986).
- *Relevant professional employment history:* ADM Associates, Energy Engineer (1986-1987); Sun Up Design, Energy Consultant (1987); Berkeley Solar Group, Engineer (1987-1990); LBNL, Staff Research Associate (1990-present).
- *Relevant professional activities and honors:* Professional Licenses: Professional Engineer, Mechanical Engineering (California); General Building Contractor (California). American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE) Standards Committee; Chair of Standards Project Committee 118.2, Method of Testing for Rating Residential Water Heaters; Chair of Technical Committee 6.6, Service Water Heating Research Subcommittee; Voting Member of Technical Committee 6.6. Formerly Chair of Standards Project Committee 118.1, Method of Testing for Rating Commercial Gas, Electric and Oil Service Water Heating Equipment; Chair of the Project Monitoring Subcommittee of Research Project 1172, Metering Residential Hot Water By End Use; and voting member of Standards Project Committee 146P, Method of

Testing for Rating Pool and Spa Heaters. Member of the American Society of Mechanical Engineers, the American Society of Plumbing Engineers, the American Solar Energy Society, and the American Water Works Association.

- *Relevant publications not emanating from this project*: More than 30 publications, including:

  Healy, William; Lutz, James D.; Lekov, Alex, *Variability in Energy Factor Test Results for Residential Electric Water Heaters*, LBNL-51665, Vol. 9, No. 4, HVAC&R Research Journal, October 2003.

  ASHRAE/ANSI Standard 118.1-2003, *Method of Testing for Rating Commercial Gas, Electric and Oil Service Water Heating Equipment*, June 2003.

  Lutz J D., Whitehead C D., Lekov A B., Liu X. , and McMahon J.E., *A Monte Carlo Approach to the Calculation of Energy Consumption for Residential Gas-Fired Water Heaters*, ASHRAE Trans., 2000, Vol.106, Part 2, Paper number MN-00-15-03, LBNL-44829

  Lekov A.B., Whitehead C D., Lutz J D., and McMahon J.E., *Cost of Increased Energy Efficiency for Residential Water Heaters*, ASHRAE Trans., 2000, Vol.106, Part 2, Paper number MN-00-15-02, LBNL-44830

  Lutz J D., Lekov A B., and Whitehead C D., *Residential Water Heaters: The Impact of Regulatory Changes*, 51st Annual International Appliance Technical Conference, Lexington, KY, May 2000, LBNL-44831

  Lutz J D., *Demonstrating Economic Justification - Updating Water Heater Efficiency Standards,* Proceedings of the 2000 ACEEE Summer Study on Energy Efficiency in Buildings, Asilomar, CA, August 2000, LBNL-45829

  Chaitkin S.D., Whitehead C D., Van Buskirk R.D., Lutz J D., and McMahon J.E. *Estimating Marginal Residential Energy Prices in the Analysis of Proposed Appliance Energy Efficiency Standards*, Proceedings of the 2000 ACEEE Summer Study on Energy Efficiency in Buildings, Asilomar, CA, August 2000, LBNL-44230

  Lekov A B., Lutz J D., Whitehead C D., and McMahon J.E., *Payback Analysis of Design Options for Residential Water Heaters,* 2000 ACEEE Summer Study on Energy Efficiency in Buildings, Asilomar, CA, August 2000, LBNL-45312

  Lekov A B., Lutz J D., Liu X., Whitehead C D., and McMahon J.E., *Determining Benefits and Costs of Improved WH Efficiencies,* 35th Intersociety Energy Conversion Engineering Conference, Las Vegas, NV, July 2000, LBNL-45618

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- *Role in the project*: Project Manager, Distribution Transformers
- *Principal areas of research and expertise*: Economic and engineering analysis of energy efficiency in buildings and equipment, large-scale field instrumentation and data analysis, thermal comfort
- *Percentage of time devoted to the project*: 26%

- *Education*: BA, Mathematics/Economics (Whitman College); MBA, Finance (University of Washington); Licentiate, Building Services Engineering, and PhD, Building Services Engineering (Chalmers University of Technology, Gothenburg Sweden).
- *Relevant professional employment history:* Pacific Northwest National Laboratory, Research Scientist, Program Manager, Group Leader (1975-1998); Chalmers University of Technology, Guest Researcher (1998-2001); Lawrence Berkeley National Laboratory, Program Manager (2001-present).
- *Relevant professional activities and honors:* American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE).
- *Relevant publications not emanating from this project*: Publications include:

Stoops, J. L. 1998. "Managing the Practical Challenges in Large End-Use Metering Projects." For *Improving Electricity Efficiency in Commercial Buildings*. 21-23 September 1998 Amsterdam, The Netherlands.

Stoops, J. L., and M. H. Sherman, 1994. Co-editors - Proceedings of the American Council for an Energy Efficient Economy 1994 Summer Study on Energy Efficiency in Buildings, Volumes 1 - 10. August 23 – September 3, 1994, Pacific Grove, California. American Council for an Energy-Efficient Economy (ACEEE), Washington, D.C.

Halverson, M. A., J. L. Stoops, J. R. Schmelzer, W. D. Chvala, J. M. Keller, and L. Harris. 1994. "Lighting Retrofit Monitoring for the Federal Sector – Strategies and Results at the DOE Forrestal Building." In Proceedings of the American Council for an Energy Efficient Economy 1994 Summer Study on Energy Efficiency in Buildings, Vol. 2, pp 2.137-2.144. August 23 – September 3, 1994, Pacific Grove, California. American Council for an Energy-Efficient Economy (ACEEE), Washington, D.C.

Stoops, J. L., et al. 1991. "Building Energy Monitoring." Chapter 37 in *1992 HVAC Applications - ASHRAE Handbook*, ed. R. A. Parsons, pp. 37.1-37.14. American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc., Atlanta, Georgia.

Stoops, J. L. 1990. "End-Use Profile Development From Whole Building Data Combined With Intensive Short Term Monitoring." For *Innovative Monitoring Approaches in Buildings*. June 22-26, 1991, Indianapolis, Indiana.

Stoops, J. L., and R. G. Pratt. 1990. "Empirical Data for Uncertainty Reduction." For *ACEEE 1990 Summer Study*. August 26 - September 1, 1990, Pacific Grove, California.

Conner, C. C., J. L. Stoops, and M. A. Halverson. 1990. "The Practical Challenges of Converting End-Use Data Into Information." In *End-Use Load Information and Its Role in DSM*, pp. (session one, projects). July 11-13, 1990, Irvine, California.

Dr. Robert Van Buskirk, Lawrence Berkeley National Laboratory (LBNL), 1 Cyclotron Road, MS-90R4000, Berkeley, CA 94720-8136, Tel: 510-495-2310, Fax: 510-486-6996, Email: RDVanBuskirk@lbl.gov.

- *Role in the project*: Chief Analyst

- *Principal areas of research and expertise*: Planning, development, and production of energy and energy efficiency policy analysis. Development of policy analysis models, software, and spreadsheet tools. Applications include the economic feasibility analysis of appliance, efficiency standards and programs in the U.S. and internationally. Supervision of research in the economics of policy impacts, costs and benefits. Development of integrated economic, meteorological, and air quality models for air quality policy analysis.
- *Percentage of time devoted to the project*: 18%
- *Education*: B.A., Physics & Mathematics (Univ. of California, Berkeley, 1984); M.A., Physics (Harvard University, 1986); Ph.D., Physics (Harvard University, 1991).
- *Relevant professional employment history:* Natural Resources Consulting Engineers, Modeling Specialist (1991-1993); University of Asmara, Eritrea, Assistant Professor/Fulbright Scholar (1993-1996); Eritrea Technical Exchange, System Administrator/Developer (1995-1997); Eritrea Department of Energy, Senior Research Scientist (1995-1997); Calmar Online Communications Ltd., Hong Kong/Beijing, Technical Project Manager (1997-1998); San Jose State University, Adjunct Professor (1997-1999); LBNL, Principal Research Associate (1999-2000); Santa Clara University, Adjunct Professor (2004-present); Department of Meteorology, San Jose State University, Adjunct Professor (2002-present); LBNL, Scientist (2000-present).
- *Relevant professional activities and honors:* Lab Director's Research Development grant: "Evaluation of dyanamic air quality impacts of distributed generation," October 2002; Outstanding Performance Award, Lawrence Berkeley National Laboratory, October 2001; J. William Fulbright Lecturer Award, September 1993 - September 1994.
- *Relevant publications not emanating from this project*:

Dale, Larry, Dey Millstein, Katie Coughlin, Robert Van Buskirk, Greg Rosenquist, Alex Lekov, Sanjib Bhuyan. 2004. "An Analysis of Price Determination and Markups in the Air-Conditioning and Heating Equipment Industry." LBNL-5279.

Coughlin, Katie and Robert Van Buskirk. 2002. Efficiency policy analysis with temporally and regionally varying energy costs. IEECB-RL5 Conference, May 28-31, 2002, Nice, FRANCE.

Van Buskirk, Robert and Katie Coughlin. 2002. Measuring National and Regional Trends and Transformations in Electricity Use, Efficiency, and Conservation. IEECB-RL5 Conference, May 28-31, 2002, Nice, FRANCE.

Rosenquist, Greg, P. Chan, A. Lekov, J. McMahon, and R. Van Buskirk. 2002. "Consumer Life-Cycle Impacts of Energy Efficiency Standards for Residential-Type Central Air Conditioners and Heat Pumps," ASHRAE Winter Meeting, January 12-16, 2002, Atlantic City, New Jersey, U.S.A.

Coughlin, Katie and Robert Van Buskirk. 2001. "Boom/Bust Cycles in Electricity Infrastructure Development," EPRI 13-th Forecasting Symposium: Price

and Load Forecasting in Volatile Energy Markets, November 13-15, 2001, Nashville, TN.

Van Buskirk, R., K. Coughlin, and E. Rendek. 2001. "Modeling Price-Load Relationships in Electricity Markets," EPRI 13-th Forecasting Symposium: Price and Load Forecasting in Volatile Energy Markets, November 13-15, 2001, Nashville, TN.

Van Buskirk, Robert. 2000. "Econometric modeling of the effects of energy efficiency standards on appliance shipments," In Proceedings 2000 ACEEE Summer Study on Energy Efficiency in Buildings, 9.371, American Council for an Energy-Efficient Economy, Washington D.C.

Chaitkin, S., G. Rosenquist, C. Dunham Whitehead, R. Van Buskirk, and J.E. McMahon. 2000. Estimating and applying marginal energy prices in the analysis of proposed appliance energy efficiency standards in the residential sector, submitted to the 2000 ACEEE Summer Study on Energy Efficiency in Buildings.

Dr. Larry Dale, Lawrence Berkeley National Laboratory (LBNL), 1 Cyclotron Road, MS-90R4000, Berkeley, CA 94720-8136, Tel: 510- 495-2477, Fax: 510-486-6996, Email: LLDale@lbl.gov.

- *Role in the project*: Economist/scientist: Estimate distribution markups, discount rates, and employment impacts, and research tax impacts on LCC results, appropriate LCC procedures, and price impacts of efficiency standards.
- *Principal areas of research and expertise*: Water energy economics, energy economics, and energy market and pricing.
- *Percentage of time devoted to the project*: 3%
- *Education*: Ph.D., Agricultural Economics (University of Hawaii, 1990); M.S., Agricultural Economics (University of California, Davis); B.A., Economics (University of California, Davis).
- *Relevant professional employment history:* Forest and Range Experiment Station, Economist (1979-1982); East West Center, Fellow (1983-1987); University of Santa Clara, Professor, Consultant (1995-2002); LBNL, Economist/Scientist (2001-present).
- *Relevant publications not emanating from this project*:

Hayhoe, Katharine, Larry Dale, et al. 2004. "Emissions Pathways, Climate Change, and Impacts on California," in *Proceedings of the National Academy of Sciences*. August 16, 2004.

Dale, Larry, C.D. Whitehead, and N. Williams. 2003. "Trends in the Adoption of Residential Water Meters in California" in *Advances in Water Supply Management.* Cedo Maksimovic and David Butler. September 2003, Palkema Publishers.

Paper presented at the Computer and Control in the Water Industry (CCWI) Conference in London, August 2003.

Dale, Larry, K.Coughlin, G.Rosenquist, A.Lekov and D. Millstein. 2003. "Markups for Equipment Price Determination." June 2003. LBNL-52791.

Sathaye, Jayant, Willy Makundi and Larry Dale. 2003. Estimating Forestry Climate Mitigation Potential and Costs: A Partial Equilibrium Approach and Indonesia Case Study. Presented at the Energy Modeling Forum (EMF 21). March 2003. *Energy Journal*. Accepted 2005.

Dale, Larry, Camilla Dunham Whitehead, and Andre Fargeix. 2003. "Electricity Price and Southern California's Water Supply Options." *Resources, Conservation and Recycling*, March 2004.

Dale, Larry, Camille Antinori, Michael McNeil and Jim McMahon. 2003. "Retrospective evaluation of declining prices for energy efficiency appliances." In *Energy Efficiency in Domestic Appliances and Lighting (EEDAL'03) conference proceedings.* September 2003.

Dale, Larry and Michael Roberts. 2005. "Discount rates applied to energy conservation projects." June 2005. LBNL-50442.

Dale, Larry. 2003. "The Benefits of Appliance Efficiency Standards to Landlords and Tenants." Draft work. June 2003. LBNL – 53070.

Rosenquist, Greg, Katie Coughlin, Larry Dale, James McMahon and Steve Meyers. 2004. Life-cycle Cost and Payback Period Analysis for Commercial Unitary Air Conditioners. March 2004. LBNL-54244.

16. Other Information Sources:

More information on the project can be found on the following websites:

- http://www.eere.energy.gov/buildings/appliance_standards/residential/furnaces_boilers.html
- http://www.eere.energy.gov/buildings/appliance_standards/commercial/distribution_transformers.html
- http://eappc76.lbl.gov/tmacal/ees.cfm

PROJECT DESCRIPTION

1. Project Title: U.S. DOE Energy Conservation Standards: Manufacturer Impact Analysis.

2. Principal Investigator:

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3. Other Participating Organizations: Project Managers, U.S. Department of Energy

4. Project:

Distribution Transformers:

1. Schedule
   a. Initiation Date: November 1, 2000
   b. Dates of Intermediate Phase Completions or Go/No-Go Points: Advance Notice of Proposed Rulemaking (ANOPR) published July 29, 2004; ANOPR Public Meeting on September 28, 2004; ANOPR Comment Period ended November 9, 2004.
   c. Original Expected Completion Date: "The Regulatory Plan and the Unified Agenda of Federal Regulatory and Deregulatory Actions" (69 FR 72712-72713) (commonly referred to as the *Regulatory Agenda*) calls for the Notice of Proposed Rulemaking (NOPR) to be published in September, 2006. It is scheduled to be published in September, 2006. Prior to publishing the NOPR, the *Regulatory Agenda* calls for a Technical Support Document (TSD) to be reviewed by the Department by September, 2005.
2. Funding Status: NCI is under subcontract with Research and Development Solutions (RDS), LLC, under the RDS Prime Contract with the National Energy Technology Laboratory (NETL).
3. Project/technology maturity – Analysis

   The focus of the Distribution Transformers standards rulemaking is to publish a Final Rule that promulgates energy conservation standards for this product. As part of the rulemaking, in-depth technical analyses are conducted and published, detailing the impacts of potential efficiency standards on production costs (i.e., cost to manufacture), consumer life-cycle cost, national energy savings, and manufacturer profitability, environmental impacts, and national employment.

Residential Furnaces and Boilers:

1. Schedule
    a. Initiation Date: July 17, 2001
    b. Dates of Intermediate Phase Completions or Go/No-Go Points: Advance Notice of Proposed Rulemaking (ANOPR) published July 29, 2004; ANOPR Public Meeting on September 29, 2004; ANOPR Comment Period ended November 10, 2004.
    c. Original Expected Completion Date: "The Regulatory Plan and the Unified Agenda of Federal Regulatory and Deregulatory Actions" (69 FR 72712-72713) (commonly referred to as the *Regulatory Agenda*) calls for the Notice of Proposed Rulemaking (NOPR) to be published in September, 2006. It is scheduled to be published in September, 2006. Prior to publishing the NOPR, the *Regulatory Agenda* calls for a Technical Support Document (TSD) to be reviewed by the Department by September, 2005.
2. Funding Status: NCI is under subcontract with Research and Development Solutions (RDS), LLC, under the RDS Prime Contract with NETL.
3. Project/technology maturity – Analysis
    The focus of the Residential Furnaces and Boilers standards rulemaking is to publish a Final Rule that promulgates energy conservation standards for this product. As part of the rulemaking, in-depth technical analyses are conducted and published, detailing the impacts of potential efficiency standards on production costs (i.e., cost to manufacture), consumer life-cycle cost, national energy savings, and manufacturer profitability, environmental impacts, and national employment.

5. Statement of Problem:

The Energy Policy Conservation Act (EPCA) provides seven factors to be evaluated in determining whether an appliance efficiency standard [energy conservation standard] is justified. (42 U.S.C. 6313(a)(6)(B)(i)) Two of these factors require the DOE to consider the economic impact on of standards on manufacturers and the impact of any lessening of competition. Both of these factors are assessed through the manufacturer impact analysis.

In September, 1995, the Department announced a formal effort to consider further improvements to the process used to develop appliance efficiency standards. The Department called on energy efficiency groups, manufacturers, trade associations, state agencies, utilities, and other interested parties to provide input to this effort. As a result of this combined effort, the Department published *Procedures, Interpretations and Policies for Consideration of New or Revised Energy Conservation Standards for Consumer Products* (the "process rule"), 10 CFR 430, Subpart C, Appendix A. The process rule contains principles for the analysis of regulatory impacts on manufacturers. The process rules states that the Department will utilize an annual cash flow approach to determine quantitative impacts on manufacturers including a short term assessment based on the cost and capital requirements during the period between the announcement of a regulation and the time when the regulation comes into effect. Additionally it describes how, with input from manufacturers and other interested parties, the Department will develop estimates of the critical variables affecting manufacturers (such as expected changes in product prices, sales, and possible fuel switching), drawing on multiple sources of data both quantitative and qualitative. The Department also committed to analyze the impacts of a standard on different types of manufacturers, with particular attention to impacts on small manufacturers. This analysis is to be done with scenario analysis or other appropriate methods. Finally, the Department is required to assess and describe the effects of other significant regulations that will take effect within three years of the effective date of the energy conservation standard and will significantly affect the same manufacturers. This assessment is intended to capture the impacts of different DOE standards affecting multiple products made by the same manufacturing division.

6. Project Objectives:
The goal of the Manufacturer Impact Analysis is to qualitatively and quantitatively assess the impacts on manufacturers of potential energy efficiency standards. The qualitative assessment is based on a series of site visits and manufacturer interviews. The interviews aim to understand the engineering, operational, and financial impacts that companies would experience under regulation. Quantitative information including sales impacts, financial ratios, and required capital investments are gathered during the interviews which subsequently feed into a discounted cash flow model called the Government Regulatory Impact Model (GRIM). The primary quantitative output of the GRIM is the change in Industry Net Present Value (INPV) that would be experienced under various Trial Standard Levels.

7. Project History & Relationships:
This project has been a key component of DOE's energy efficiency standards rulemakings since 1979, and a critical part of the current rulemakings being analyzed by the Building Technologies Program — including the Distribution Transformer standards rulemaking and the Residential Furnaces and Boilers standards rulemaking. The Manufacturer Impact Analysis, and more specifically the GRIM model, draws many of its inputs from other analysis sections, including production costs from the engineering analysis and shipments forecasts from the national energy savings analysis.

8. Technical Approach:
The Department conducts the MIA primarily during the NOPR phase of the rulemakings. This analysis estimates the financial impact of standards on manufacturers and also calculates the impact of standards on competition, direct employment, and manufacturing capacity within the industry. Four important elements of the approach are the industry characterization, the interview process, preparation of an industry cash flow model, and the development of a sub-group cash flow analysis.

- Industry Characterization – The first step of the MIA is to collect pertinent financial and market information. Data gathered include market share, corporate operating ratios, wages, employment, and production cost ratios. Sources of information typically used for this research include experts from industry as well as reports published by industry groups, trade journals, the U.S. Census Bureau, and SEC 10-K filings.

- Interview Process - The rulemaking process provides for extensive public input, with particular emphasis on earlier and more-extensive information gathering from interested parties. The interview process has a key role in the MIAs, 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. A detailed interview guide is prepared and distributed to manufacturers prior to site visits to focus and facilitate the interviews.

- Industry Cash Flow Analysis – The GRIM utilizes a number of factors such as annual expected revenues; manufacturer costs such as cost of goods sold; selling, general and administrative expenses (SG&A); property taxes; and capital expenditures to arrive at a series of annual cash flows. Industry Net Present Value is calculated by discounting the annual cash flows from the period before implementation of standards to some future point in time at the estimated industry weighted average cost of capital.

- Manufacturer Sub-Group 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 affected asymmetrically by standards. In highly concentrated industries it is possible to calculate the impacts on each firm. In industries having numerous participants, the results of the industry characterization are used to group manufacturers exhibiting similar characteristics. The industry GRIM serves as a benchmark against which manufacturer sub-groups are analyzed.

9. Technical Work Plan:

The Department conducts the manufacturer impact analysis (MIA) in three phases. Phase 1 consists of two activities: preparation of an industry characterization and identification of issues. Phase 2 focuses on the larger industry and, in this phase, DOE uses the Government Regulatory Impact Model (GRIM) to perform an industry cash flow analysis. In addition, phase 2 involves developing an interview guideline and questionnaire for use in phase 3. At the beginning of phase 3, the Department interviews manufacturers and adjusts the industry cash flow analysis as appropriate. Phase 3 also entails performing additional cash flow analyses for the different sub-groups that may be affected by the rulemaking. Furthermore, in phase 3, DOE studies the additional impacts on competition, manufacturing capacity, employment and the cumulative burden of other regulations impacting manufacturers.

9.1 1Phase 1: Industry Profile

Phase 1 of the MIA consists of collecting pertinent financial and market information. This activity involves both quantitative and qualitative efforts. Data gathered include market share, corporate operating ratios, wages, employment, and production cost ratios. Sources of information include reports published by industry groups, trade journals, and the U.S. Bureau of Census, and copies of Securities and Exchange Commission (SEC) 10-K filings.

The Department relies on the information gathered for the market assessment, engineering analysis, and life-cycle cost analysis. This includes manufacturer market shares, markups along the distribution chain, and typical ratios for labor, materials, and overhead.

9.2 1Phase 2: Industry Cash Flow Analysis

In Phase 2, the Department performs a preliminary industry cash flow analysis and prepares a manufacturer interview guide.

The industry cash flow analysis relies primarily on the GRIM. The Department uses the GRIM to analyze the financial impacts of more stringent energy efficiency standards on the industry that produces the products covered by the standard. A change in standards affects the analysis in three distinct ways. Standards at higher levels will require additional investment, raise production costs, and affect revenue through higher prices and, possibly, lower quantities sold. The Department quantifies these changes through the use of the GRIM.

The GRIM analysis uses a number of factors to determine annual cash flows from a new standard: annual expected revenues; manufacturer costs (including cost of goods sold, capital depreciation, R&D, selling, and general administrative costs); and conversion expenditures. The Department compares the results against baseline projections that involve no new standards. The financial impact of new standards is then the difference between the two sets of discounted annual cash flows. Other performance metrics, such as return on invested capital, are also available from the GRIM.

This analysis uses manufacturing costs, shipments forecasts, and price forecasts developed for the other analyses. The Department develops financial information, also required as an input to the GRIM, based on publicly available data and confidentially submitted manufacturer information. The Department prepares and distributes to the manufacturers estimates of the financial parameters used in the industry cash flow analysis.

The Department conducts interviews with manufacturer representatives to gather key information on the effects that higher efficiency standard levels might have on their company's revenues and finances, direct employment, capital assets, and competitiveness.

These interviews take place during Phase 3 of the MIA. Prior to the interviews, the Department distributes an interview guide that provides a starting point to identify relevant issues and to help identify, both qualitatively and quantitatively, the impacts of possible candidate standard levels on individual manufacturers or sub-groups of manufacturers.

9.3 Phase 3: 1Sub-Group Analysis
The Phase 3 activities take place after the publication of the Advanced Notice of Proposed Rulemaking (ANOPR) and include: manufacturer interviews; revising the industry cash flow analysis; manufacturer sub-group cash flow analysis; competitive impact assessment; manufacturing capacity impact; employment impact; and cumulative regulatory burden.

Manufacturer Interviews
The information gathered in Phase 1 and the cash flow analysis performed in Phase 2 are supplemented with information gathered during interviews with manufacturers during Phase 3. The interview process has a key role in the manufacturer impact analyses, since it provides an opportunity for interested parties to privately express their views on important issues, allowing DOE to consider confidential or sensitive information in the rulemaking decision.

The Department’s contractors conduct detailed interviews with as many manufacturers as is necessary to gain insight into the range of potential impacts of standards. During the interviews, the Department solicits information on the possible impacts of potential efficiency levels on sales, direct employment, capital assets, and industry competitiveness. Both qualitative and quantitative information are valuable. The Department schedules interviews well in advance to provide every opportunity for key individuals to be available. Although a written response to the questionnaire is acceptable, DOE prefers an interactive interview process because it helps clarify responses and provides the opportunity to identify additional issues.

The Department’s contractors request that interview participants identify all confidential information provided in writing or orally. The Department considers all information transmitted to its contractors, as appropriate, in its decision-making process. However, it does not make confidential information available in the public record. Participants are also asked to identify all information they wish to be included in the public record but that they do not want to have associated with their interview. The Department’s contractor incorporates this information into the public record but reports it without attribution.

Manufacturer Sub-Group Analysis
Using average cost assumptions to develop an industry cash flow estimate is not adequate for assessing differential impacts among sub-groups of manufacturers. Smaller manufacturers, niche players, or manufacturers exhibiting a cost structure that differs largely from the industry average could be more negatively impacted. The Department uses the results of the industry characterization to group manufacturers exhibiting similar characteristics.

During the interview process, the Department discusses the potential sub-groups and sub-group members that it has identified for the analysis. The Department looks to the manufacturers and other stakeholders to suggest what sub-groups or characteristics are the most appropriate for the analysis.

Competitive Impact Assessment

Section 325(o)(2)(B)(i)(V) directs the Department to consider any lessening of competition that is likely to result from imposition of standards. It further directs the Attorney General to determine the impacts, if any, of any lessening of competition. The competitive analysis focuses on assessing the impacts to smaller, yet significant, manufacturers. The Department bases its assessment on manufacturing cost data and on information collected from interviews with manufacturers. The manufacturer interviews 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 (e.g., proprietary technologies).

Manufacturing Capacity Impact

One of the significant outcomes of new standards could be the consequential obsolescence of existing manufacturing assets, including tooling and investment. The manufacturer interview guide addresses a series of issues to help identify impacts on manufacturing capacity, specifically:

- capacity utilization and plant location decisions in the U.S. and North America with and without a standard level;
- the ability of manufacturers to upgrade or remodel existing facilities to accommodate the new requirements;
- the nature and value of stranded assets, if any; and
- estimates for any one-time restructuring and other charges, where applicable.

Employment Impacts

The impact of new energy-efficiency standards on employment is an important consideration in the rulemaking process. To assess how domestic employment patterns might be affected, the interview guide explores current employment trends in the distribution transformer industry. In addition, the interview solicits manufacturer views on changes in employment patterns that may result from increased standard levels. The employment impacts section of the interview guide typically focuses on:

- current employment levels at each of their production facilities;
- expected future employment levels with and without a standard; and
- differences in workforce skills and issues related to the retraining of employees.

Cumulative Regulatory Burden

The Department recognizes and seeks to mitigate the overlapping effects on manufacturers of amended DOE standards and other regulatory actions affecting the same equipment or companies.

10. Technical Problems/Barriers:

Manufacturer Involvement/Preparation: Manufacturer interviews draw upon the experience of members from various departments in each company including R&D, engineering, finance, and marketing. Participating companies must devote considerable resources to prepare for the interviews.

Confidentiality of Data: The data needed to assess the manufacturer impacts are highly sensitive: pricing strategies, product development plans, production processes and costs, employment levels etc. A considerable level of trust and confidentiality assurances are needed to allow for the needed communication.

Number of Firms: Industries vary considerably in the number manufacturers involved in the production of regulated products. Major US-based home appliance manufacturers are very few. Transformer manufacturers in contrast number almost 100. The paperwork reduction act limits the number of manufacturers that can be surveyed. Department resources also limit the number of firms that can be interviewed.

11. Status of Milestones:

For the standards rulemakings discussed here—distribution transformers and residential furnaces and boilers. Screening and engineering analyses were conducted for each product's Advance Notice of Proposed Rulemaking (ANOPR). Both the distribution transformers and residential furnaces and boilers ANOPRs were published on July 29, 2004.

According to the *Regulatory Agenda*, the NOPRs for distribution transformers and residential furnaces and boilers are both scheduled to be published in September, 2006. Prior to publishing the NOPRs, the *Regulatory Agenda* calls for TSDs to be reviewed by the Department by September, 2005. Because TSDs are required to be completed and reviewed by September, 2005, the Screening and Engineering analyses had to be revised by May, 2005. Both of these analyses have been completed.

12. Efficiency Improvement Metrics:

There are ten product classes of DT that are being analyzed, consisting of thirteen design lines. The ten product classes are divided into classes of liquid-type transformers, typically used by electric utilities, and dry-type transformers, which are typically used at commercial and industrial building sites. The energy descriptor for DT is *efficiency*, which measures the total energy losses at a design load of 50 percent for liquid-type transformers and 35 percent for dry-type transformers. The cost of achieving higher transformer efficiency varies significantly over the product classes. The purpose of the NES/NPV part of the national impact spreadsheet is to calculate some of the key quantities by which a candidate energy efficiency standard may be evaluated. Two such quantities are national source energy savings and NPV. Source energy is total energy saved (or reduction in losses) by transformers. NPV is a measure of the net benefit to consumers due to an energy-efficiency standard.

13. Project Output:
Major Accomplishments:

For distribution transformers, the major accomplishments are the publication of the Technical Support Document and the Analytical Spreadsheets that accompanied the ANOPR:

- U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy, *Technical Support Document: Energy Efficiency Program for Commercial and Industrial Equipment: Electrical Distribution Transformers*, July, 2004. Washington, DC. <http://www.eere.energy.gov/buildings/appliance_standards/commercial/dist_trans_tsd_061404.html>
- U.S. Department of Energy-Office of Energy Efficiency and Renewable Energy, ANOPR Analytical Spreadsheets, ANOPR engineering analysis results spreadsheets for all 13 design lines, April 2004. Washington, DC. <http://www.eere.energy.gov/buildings/appliance_standards/commercial/distribution_transformers_spreadsheets.html>

For FB, the major accomplishments are the publication of the Technical Support Document and the Analytical Spreadsheets that accompanied the ANOPR:

- U.S. Department of Energy-Office of Energy Efficiency and Renewable Energy, *Technical Support Document: Energy Efficiency Program for Consumer Products: Energy Conservation Standards for Residential Furnaces and Boilers*, September, 2004. Washington, DC. < http://www.eere.energy.gov/buildings/appliance_standards/residential/furnaces_boilers_1113_r.html>
- U.S. Department of Energy-Office of Energy Efficiency and Renewable Energy, Residential Furnaces and Boilers ANOPR Analytical Tools, September, 2004. Washington, DC. <http://www.eere.energy.gov/buildings/appliance_standards/residential/furnace_boiler_draft_analysis.html>

14. Principal Project Personnel:

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- *Role in the project*: Principal Investigator
- *Principal areas of research and expertise*: Financial analysis and valuation, market and technology analysis, and strategic planning. Assisted the Department of Energy in the development of new policies and procedures to review and update energy efficiency regulations for residential and commercial appliances. Managed the collaborative development of a new economic impact analysis

methodology to determine the likely impacts of appliance standards on appliance and equipment manufacturers. Directed the manufacturer impact analyses for fluorescent lamp ballasts, clothes washers, water heaters, and central air conditioners.

- *Percentage of time devoted to the project*: 10%
- *Education*: Master of Science, Technology and Policy, MASSACHUSETTS INSTITUTE OF TECHNOLOGY**;** Master of Business Administration, CONCORDIA UNIVERSITY; Bachelor of Engineering, Electrical Engineering, McGILL UNIVERSITY.
- *Relevant professional employment history*: Central Plumbing and Electricity Ltd, Director - Electrical Contracting (1982 to 1986); The Centco Group Inc, President (1986 to 1994); Arthur D. Little Inc, Director (1995 to 2002); Navigant Consulting Inc, Managing Director (2002-present).
- *Relevant professional activities and honors*: President 1994-1995, Vice-President 1992-1993, Quebec Natural Gas Association; Board Member 1993-1994, Natural Gas Technology Center (Quebec); Board Member 1991-1994, Provincial Council for Training in the Construction Industry (Quebec); Board Member 1991- 1994, Centre Antonio-Barrette Trade School; Member, Training committee of the Quebec Association of Consulting Engineers 1993; Member, Gas Utility-Contractor joint committee on appliance servicing.

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- *Role in the project*: Project Manager, Distribution Transformers
- *Principal areas of research and expertise*: Developing energy performance standards for commercial and residential equipment, as well as studying market barriers and transformation activities for energy efficient products.
- *Percentage of time devoted to the project*: 33%
- *Education*: Master of Science, Civil and Environmental Engineering, Bachelor of Science, Mechanical Engineering and Environmental Studies, TUFTS UNIVERSITY.
- *Relevant professional employment history:* International Institute for Energy Conservation-Europe, Project Manager, (1994 to 1996); International Institute for Energy Conservation-Africa, Program Manager, (1997 to 1999); PW Consulting, Database Analyst**,** (1999 to 2000); Arthur D. Little, Inc., Consultant, (2000 to 2002); Navigant Consulting, Inc, Managing Consultant, (2002 to Present).
- *Relevant professional activities and honors:*
    - *Certificate of Appreciation*, United States Department of Energy, Bill Richardson, Secretary of Energy, for exemplary contribution in support of the Lighting and Appliance Standards Program, December 2000
    - Member, Tau Beta Pi (national engineering honors society)
    - Association of Energy Engineers scholarship, Boston Chapter
- *Relevant publications not emanating from this project*:

- *Analyzing Barriers and Designing Market Transformation Programs for Energy Efficient Technology*, co-author, 2004 ACEEE Summer Study on Energy Efficiency in Buildings, Pacific Grove, California, August 2004
- *Energy Savings Estimates of Light Emitting Diodes in Niche Lighting Applications*, co-author, 2004 ACEEE Summer Study on Energy Efficiency in Buildings, Pacific Grove, California, August 2004
- *Technical Support Document: Energy Efficiency Program for Commercial and Industrial Equipment: Energy Conservation Standards for Distribution Transformers*, co-author, July 2004.
- *Energy Savings Potential of Solid-State Lighting in General Illumination Applications*, report author, prepared for the U.S. Department of Energy, November 2003
- *U.S. Lighting Market Characterization, Volume I: National Lighting Inventory and Energy Consumption Estimate*, report co-author, prepared for the U.S. Department of Energy, September 2002
- *Appliance Efficiency Standards Take Off*, Vital Signs 2002, Worldwatch Institute, Washington, D.C., May 2002

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- *Role in the project*: Project Manager, Distribution Transformers
- *Principal areas of research and expertise*: Development of energy efficiency standards for consumer products and commercial equipment, as well as analyzing renewable energy technologies and markets.
- *Percentage of time devoted to the project*: 33%
- *Education*: Master of Science, Technology and Policy, MASSACHUSETTS INSTITUTE OF TECHNOLOGY; Master of Science, Environmental Engineering, CLEMSON UNIVERSITY; Bachelor of Science, Chemical Engineering, BUCKNELL UNIVERSITY
- *Relevant professional employment history*: Massachusetts Institute of Technology, Researcher, (1999 to 2001); Antares Group, Inc., Project Manager, (2001 to 2003); Navigant Consulting, Inc., Senior Consultant, (2003 to present).
- *Relevant professional activities and honors*: Recipient of Oak Ridge Institute for Science and Education Fellowship (1997); Martin Sustainability Fellow, MIT (2000).
- *Relevant publications not emanating from this project*:
    - Fjeld, R.A., S.M. Serkiz, B.W. Gibbs, P.L. McGinnis, J.T. Coates. "Evaluation of a Conceptual Model for the Subsurface Transport of Plutonium Involving Surface Mediated Reduction of Pu(V) to Pu(IV)." Paper presented at the 8th International Conference on Chemistry and Migration Behaviour of Actinides and Fission Products in the Geosphere, Bregenz, Austria (2001). Results of laboratory analysis originally presented at the 1998 Health Physics Society's annual conference in Minneapolis, MN.

- Gibbs, Barclay and Bruce Biewald, "Transmitting Windpower from the Dakotas to Chicago: A Preliminary Analysis of a Hydrogen Transmission Scenario." Paper presented at the 12th Annual Meeting of the US National Hydrogen Association, the Annual Meeting of the American Wind Energy Association (2001), the World Congress for a Hydrogen Economy (Denver, 2001), and the First International Conference for the Hydrogen Century (Tokyo, 2001).
- Gibbs, Barclay, 2001, "Increasing the Gasoline Tax in Mexico City: A Potential Policy Option to Supplant Early Implementation of Tier 2 Tailpipe Standards," Masters Thesis, Massachusetts Institute of Technology. Contribution to forthcoming MIT publication.

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- *Role in the project*: Project Manager, Residential Furnaces and Boilers, Cost Modeling
- *Principal areas of research and expertise*: Design for assembly, inventory control, manufacturing line layout, reliability, cost reduction, technical cost modeling, quality control, plant siting, lifecycle costing, high-volume processing, reverse engineering, tooling design, and evaluation of capital equipment.
- *Percentage of time devoted to the project*: 10%
- *Education*: Master of Science, Manufacturing Engineering, UNIVERSITY OF RHODE ISLAND; Bachelor of Science, Physics, YALE UNIVERSITY.
- *Relevant professional employment history*: Thermal Ceramics, Process Engineer, (1992 –1993); Wesgo Ceramics, Process Engineer, (1995-1996); Powis Parker, Inc., Manufacturing Engineer, (1997 – 1998); TIAX LLC (formerly Arthur D. Little, Inc.), Consultant (1999 – 2002); Navigant Consulting, Senior Consultant (2002 to present).
- *Relevant professional activities and honors*:
  - US Patents: 5645627, Charge stabilized electret filter media; 6609274, Refrigerator Handle Assembly; 6780226, Charge stabilized electret filter media.

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- *Role in the project:* Project Manager, Residential Furnaces and Boilers
- *Principal areas of research and expertise:* Energy efficiency of mechanical equipment and technical analysis and evaluation of consumer products and commercial equipment.
- *Percentage of time devoted to the project:* 25%

- *Education:* PhD, Mechanical Engineering, UNIVERSITY OF MARYLAND COLLEGE PARK; Master of Engineering, Engineering Management, CATHOLIC UNIVERSITY OF AMERICA; Bachelor of Science, Mechanical Engineering, UNIVERSITY OF MARYLAND COLLEGE PARK.
- *Relevant professional employment history*: General Services Administration, Mechanical Engineer, (1992 to 1999); Center for Environmental Energy Engineering, University of Maryland College Park, Manager of the Building Cooling, Heating and Power Project, (1999 to 2002); Navigant Consulting, Inc., Senior Consultant, (2002 to present).
- *Relevant professional activities and honors:* American Society of Heating, Refrigeration, and Air-Conditioning Engineers Member; Association of Energy Engineers Foundation Scholarship; UT-Battelle Educational Institution of the Year Award, BCHP project in support of Oak Ridge National Laboratory; GSA Regional Administrator's Enterprise Award; Tau Beta Pi National Engineering Honor Society Member.
- *Relevant publications not emanating from this project:*
  - Marantan, A., "Optimization of Integrated Microturbine and Absorption Chiller Systems in CHP for Buildings Applications," Doctoral Dissertation, University of Maryland, College Park, December, 2002.
  - Wongsosaputro, W., A. Marantan, P. Popovic, P. Garland and R. Radermacher, *"Environmental Analysis of Two Cooling, Heating and Power Systems for Commercial Buildings,"* Energy Journal, 2002.
  - Cowie, M., A. Marantan, P. Garland, and R. Radermacher, *"CHP for Buildings: The Challenge of Delivering Value to the Commercial Sector,"* 2002 Proceedings of the ASME International Mechanical Engineering Congress and Exposition, Vol. 3 (IMECE2002), New Orleans, LA, November, 2002.
  - Popovic, P., A. Marantan, R. Radermacher and P. Garland, *"Integration of a Microturbine with a Single Effect Exhaust Driven Absorption Chiller and a Solid Wheel Desiccant System,"* ASHRAE Symposium on CHP for Buildings, ASHRAE Transactions 2002, Vol 108, Pt. 2.
  - Marantan, A., P. Popovic and R. Radermacher, *"The Potential of CHP Technology in Commercial Buildings - Characterizing the CHP Demonstration Building,"* ASHRAE Symposium on CHP Technologies for the New Century, ASHRAE Transactions 2002, Vol 108, Pt. 1.
  - Popovic, P., D. Lindsay, A. Marantan and R. Radermacher, *"Investigation of the Cost and Feasibility of the Development of Renewable Energy Projects in the State of Maryland,"* Baltimore Gas & Electric, September 2000.

Edward P. Levy, 1801 K Street N.W., Suite 500, Washington, DC 20006. Phone: 202 973 4507. Fax: 202 973 2401. Email: elevy@navigantconsulting.com URL: http://www.navigantconsulting.com

- *Role in the project*: Ensure compliance to Federal legislation governing efficiency standards and to administrative law, including the Administrative Procedures Act.
- *Principal areas of research and expertise*: Mr. Levy has worked on a range of projects on energy conservation regulation for the Department of Energy, including public notices setting forth new compliance and enforcement methods and procedures for commercial products, proposing new test methods and procedures for commercial products, proposing new test methods for distribution transformers, and addressing regulation of products not previously covered under the Department's programs.
- *Percentage of time devoted to the project*: 10%
- *Education*: Bachelor of Law, UNIVERSITY OF MICHIGAN LAW SCHOOL; Bachelor of Arts, Political Science, BROOKLYN COLLEGE.
- *Relevant professional employment history*: Department of Energy, Economic Regulatory Administration, Assistant Special Counsel for Settlements (1985 to 1987); Department of Energy, Economic Regulatory Administration, Senior Trial Attorney (1987 – 1995); Department of Energy, Office of Assistant General Counsel for Energy Efficiency, Attorney, (1995 – 2000), Arthur D. Little, Inc., Consultant (2001 – 2002); Navigant Consulting, Inc., Managing Consultant (2002-present).
- *Relevant professional activities and honors*:
  - Member of the Bar in the District of Columbia and New York State
  - Cash Award for Special Service, as Acting Deputy Director of the Office for Civil Rights, Department of Health, Education and Welfare (HEW), June 1979
  - Superior Service Award from the Secretary of HEW, October 1970

Paul K. Goethe, President and CEO, Optimized Program Service, Inc.

- *Role in the project*: Development of a database of transformer designs, with varying costs and efficiencies.
- *Principal areas of research and expertise*: Transformer design and testing.
- *Percentage of time devoted to the project*: 5%
- *Education*: Bachelor of Science, Electrical Engineering, MICHIGAN TECHNICAL UNIVERISTY; Continued graduate studies through Westinghouse sponsored advanced degree programs conducted by The University of Pittsburgh and Penn State from 1950 through 1958.
- *Relevant professional employment history*: Westinghouse, Test Engineer (1949); Westinghouse, Design Engineer, Supervising Engineer and Engineering Manager (1950-1958); Electronic Devices, Inc., Co-founder, Vice President and General Manager (1959-1969); Optimized Program Service, Inc., founder, President and CEO, (1969-present).
- *Relevant professional activities and honors*:
  - I.E.E.E. – functioned as Westinghouse representative on various standard committees. For the past thirty two years have been active in I.E.E.E.

standards development and served as National Chairman of E.T.T.C. under the auspices of the Magnetic Society and Power Electronics Society.

David A. Wiegand, P.E. Transformer Engineering Services.

- *Role in the project*: Technical consultant on transformer design, construction methods, design optimization and testing.
- *Principal areas of research and expertise*: Transformer design and manufacturing.
- *Percentage of time devoted to the project*: 5%
- *Education*: Bachelor of Science, Electrical Engineering – Power Option (Honors), University of Toronto.
- *Relevant professional employment history*: Ferranti-Packard, Reliance, and McGraw-Edison, Design Engineer (1954-1963); Westinghouse, Marketing Product Manager (1963-1974); Westinghouse, Supervisor-Design Engineering, (1974-1981); Westinghouse and ABB, Product Specialist-Transformers, (1981-1991); Transformer Engineering Services, President and CEO, (1991 to present).
- *Relevant professional activities and honors*: PEO (Professional Engineers, Ontario); IEEE Life Member; IEEE Standards Association-Transformers; CSA Chair, Technical Committee on Industrial Equipment; CSA Chair, Subcommittee on Liquid-Filled Distribution Transformer Efficiency; CSA Chair, Subcommittee on Dry-Type Transformer Efficiency
- *Relevant publications not emanating from this project:*
    - *Utility Application of Dry-Type Transformers*, MEA Project 1998
    - *Secondary Spade Connections on Pad-mounted and Vault-Installed Transformers*, MEA Project 1996
    - *A Review of the Basis of Existing Requirements for Clearances Between Padmount Transformers and Building Structures*, MEA Project 1993
    - *A Review of Research into Standard Requirements for Clearance between Three Phase Pad-Mounted Transformers and Adjacent Building Structures*, MEA Project 1995
    - *CEA Position Paper SD-286a: Replacement of Electric Insulating Oil in Distribution Equipment*, 1994
    - *Control of Transformer Losses in Canada*, IEEE 1994, Chicago

15. Other Information Sources:

More information on the project can be found on the following websites:

- http://www.eere.energy.gov/buildings/appliance_standards/commercial/distribution_transformers.html
- http://www.eere.energy.gov/buildings/appliance_standards/residential/furnaces_boilers.html
- http://eappc76.lbl.gov/tmacal/ees.cfm

PROJECT DESCRIPTION

1. Project Title: U.S. DOE Energy Conservation Standards: Other (Utility Impact, Environmental Assessment, Employment Impact, and Regulatory Impact) Analyses

2. Principal investigator:

James McMahon
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3. Other Participating Organizations: Project Managers, U.S. Department of Energy

4. Project:

Distribution Transformers:

1. Schedule
    a. Initiation Date: October 1, 2000
    b. Dates of Intermediate Phase Completions or Go/No-Go Points: Advance Notice of Proposed Rulemaking (ANOPR) published July 29, 2004; ANOPR Public Meeting on September 28, 2004; ANOPR Comment Period ended November 9, 2004.
    c. Original Expected Completion Date: "The Regulatory Plan and the Unified Agenda of Federal Regulatory and Deregulatory Actions" (69 FR 72712-72713) (commonly referred to as the *Regulatory Agenda*) calls for the Notice of Proposed Rulemaking (NOPR) to be published in September, 2006. It is scheduled to be published in September, 2006. Prior to publishing the NOPR, the *Regulatory Agenda* calls for a Technical Support Document (TSD) to be reviewed by the Department by September, 2005.
2. Funding Status: Appliance Standards projects are currently awarded on a non-competitive basis.
3. Project/technology maturity – Analysis
    The focus of the Distribution Transformers standards rulemaking is to publish a Final Rule that promulgates energy conservation standards for this product. As part of the rulemaking, in-depth technical analyses are conducted and published, detailing the impacts of potential efficiency standards on production costs (i.e., cost to manufacture), consumer life-cycle cost, national energy savings, and manufacturer profitability, air-borne emissions, and national employment.

Residential Furnaces and Boilers:

1. Schedule
    a. Initiation Date: October 1, 2000
    b. Dates of Intermediate Phase Completions or Go/No-Go Points: Advance Notice of Proposed Rulemaking (ANOPR) published July 29, 2004; ANOPR Public Meeting on September 29, 2004; ANOPR Comment Period ended November 10, 2004.
    c. Original Expected Completion Date: "The Regulatory Plan and the Unified Agenda of Federal Regulatory and Deregulatory Actions" (69 FR 72712-72713) (commonly referred to as the *Regulatory Agenda*) calls for the Notice of Proposed Rulemaking (NOPR) to be published in September, 2006. It is scheduled to be published in September, 2006. Prior to publishing the NOPR, the *Regulatory Agenda* calls for a Technical Support Document (TSD) to be reviewed by the Department by September, 2005.
2. Funding Status: Appliance Standards projects are currently awarded on a non-competitive basis
3. Project/technology maturity – Analysis

    The focus of the Residential Furnaces and Boilers standards rulemaking is to publish a Final Rule that promulgates energy conservation standards for this product. As part of the rulemaking, in-depth technical analyses are conducted and published, detailing the impacts of potential efficiency standards on production costs (i.e., cost to manufacture), consumer life-cycle cost, national energy savings, and manufacturer profitability, air-borne emissions, and national employment.

5. Statement of Problem:

For its energy-efficiency standards rulemakings, the Department of Energy must perform a variety of "other" analyses to fulfill its regulatory requirements and ensure that it has considered all potential impacts of its proposed standards. These analyses include:

- *Environmental Assessment* – This analysis fulfills the requirement that the environmental effects of all new Federal rules be quantified and considered. In addition, when DOE is determining the economic justification for its standards, EPCA directs it to consider a number of different factors, including the need for national energy conservation; DOE includes environmental benefits in this analysis.
- *Employment Impact Analysis* – The Process Rule (*Procedures for Consideration of New or Revised Energy Conservation Standards for Consumer Products*, 61 FR 36974 (July 15, 1996) includes employment impacts among the factors DOE considers in selecting a proposed standard. (The Process Rule applies to the development of energy conservation standards for consumer products, and DOE decided to apply its procedures to commercial and industrial equipment as well.)
- *Utility Impact Analysis* – For energy-efficiency standards rulemakings, the Department also analyzes the effects of proposed standard levels on the electric utility industry.
- *Regulatory Impact Analysis* – Under Executive Order 12866, the Department of

Energy is required to perform a regulatory analysis for all rules that constitute an "economically significant regulatory action." In addition, under the Process Rule, the Department is committed to continually explore nonregulatory alternatives to standards. This analysis addresses both of these needs.

The Utility Impact, Environmental Assessment, Employment Impact, and Regulatory Impact Analyses are thus essential and important activities that enable DOE's Building Technologies Program (BTP) to determine the effects of proposed standards on the Nation, ensuring that BTP fulfills EPCA's requirements and meets its goal of improving the efficiency of buildings and the equipment, components, and systems within them. Through its work prescribing energy efficiency standards, the BTP helps further EERE's mission of strengthening America's energy security, environmental quality, and economic vitality.

6. Project Objectives:

This project is designed to satisfy the legislative mandate for DOE to analyze appliance efficiency standards, and to ensure that it has thoroughly considered all potential impacts of its proposed standards.

7. Project History & Relationships:

The four analyses that compose this project have been key components of DOE's energy efficiency standards rulemakings since 1979, and critical parts of the current rulemakings being analyzed by BTP—including the Distribution Transformer standards rulemaking and the Residential Furnaces and Boilers standards rulemaking—since their inception in 2000. The results from these four analyses are established for a set of trial standard levels (each trial standard level consists of a set of minimum efficiency standards for each product class). The results from these analyses factor into DOE's selection of a proposed standard level.

The Utility Impact, Environmental Assessment, Employment Impact, and Regulatory Impact Analyses are four of the elements required for performing a full appliance standards analysis. Preceding these four analyses are the Shipments and National Impact Analyses. The national energy savings associated with a set of trial standard levels are generated by the National Impact Analysis and serve as inputs to the Utility Impact and Environmental Assessment Analyses. Also, the Life-Cycle Cost (LCC) Analysis establishes the relationship between the appliance load and the electric utility system load. This relationship is used by the Utility Impact Analysis and Environmental Assessment to ensure that the effect of any reduction in appliance energy demand on system demand is accurately captured. The National Impact Analysis, in addition to generating national energy savings, also establishes the impact that standards have on national appliance purchase costs and operating cost savings. Both sets of outputs (i.e., the national energy savings and the national purchase costs and operating cost savings) are fed into the Employment Impact Analysis to establish national employment impacts. The Regulatory Impact analysis relies on the spreadsheet tools developed for the National Impact Analysis to assess the impact of alternatives to mandatory efficiency standards.

Results from the Utility Impact, Environmental Assessment, Employment Impact, and Regulatory Impact Analyses are not used as inputs by any other appliance standards analyses.

8. Technical Approach:

Environmental Assessment: This analysis assesses the impacts of proposed standards levels on certain power plant environmental indicators, using NEMS-BT—a variant of DOE/Energy Information Administration (EIA)'s National Energy Modeling System (NEMS)—to provide key inputs to the assessment and generate the impacts. Results of the environmental assessment are similar to those provided in the EIA's *Annual Energy Outlook* (*AEO*). The assessment considers two pollutants, sulfur dioxide (SO_2) and nitrogen oxides (NOx), and one emission, carbon (tracked in the NEMS-BT as carbon dioxide, CO_2). For each of the energy-efficiency standards levels, the analysis calculates total emissions using NEMS-BT.

The Environmental Assessment is conducted as a policy deviation from the most recent *AEO*, and is based on the same basic set of assumptions (i.e., the emissions characteristics of an electricity generating plant). The analysis takes into account any factors affecting the type of electricity generation and, in turn, the type and amount of airborne emissions being generated by the utility industry. In the analysis of specific standards, the default NEMS system load shape may be substituted with one that represents weather conditions for a typical meteorological year (TMY), to ensure that the system load shapes in NEMS are consistent with the end-use load shapes used to represent any reduction in energy demand, as well as any reduction in resulting emissions, related to the appliance being analyzed.

The results of the environmental assessment are similar to a complete NEMS run, as published in the *AEO*. These include power sector emissions for SO_2, NO_x, and CO_2, and SO_2 prices, in five-year forecasted increments extrapolated to an agreed-upon year in the future. The outcome of the assessment for each trial standard level is reported as a deviation from the *AEO* reference case.

The operation of certain appliances (e.g., residential furnaces and boilers) requires the use of fossil fuels, resulting in site emissions of CO_2, NO_X, and SO_2, i.e., emissions at the sites where equipment is installed. Because NEMS-BT provides no means for estimating such site emissions, the Environmental Assessment includes separate estimates of the effect of the trial standard levels on site emissions of CO_2, NO_X, and SO_2, based on simple emissions factors derived from the literature.

Employment Impact Analysis: Employment impacts consist of the total impact on employment in the national economy, including the sector that manufactures the equipment being regulated. Using an input/output model of the U.S. economy, this analysis estimates the impacts of energy-efficiency standards on different sectors of the economy and the net impact on jobs. It estimates the effects on employment for equipment manufacturers, relevant service industries, energy suppliers, and the economy in general. Employment impacts are separated into indirect and direct impacts. Direct employment impacts will result if standards lead to a change in the number of employees at manufacturing plants and related supply and service firms. Indirect impacts are impacts on the national economy other than in the manufacturing sector being regulated. Indirect impacts might result both from expenditures shifting among goods (substitution effect), and from changes in income, which could lead to a change in overall expenditure levels (income effect). Indirect employment impacts from energy-efficiency standards are defined as net jobs eliminated or created in the general economy, as a result of increased spending on the purchase price of equipment and reduced consumer spending on energy.

The analysis relies on publicly and commercially available data sources and software to estimate employment impacts. It also utilizes a spreadsheet model, Impact of Building Energy Efficiency Programs (IMBUILD), developed by DOE's Building Technologies Program, to analyze indirect employment impacts. IMBUILD is a special-purpose version of the Impact Analysis for Planning (IMPLAN) national input-output model that specifically estimates the employment and income effects of building energy technologies. The 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. IMBUILD output includes employment, industry output, and wage income. The Department introduced into IMBUILD, as perturbations to existing economic flows, changes in expenditures due to appliance standards—and thus estimated the resulting net national impact on jobs by sector.

Utility Impact Analysis: The Utility Impact Analysis estimates the effects of reduced energy consumption, due to improved appliance efficiency, on the utility industry. This analysis consists of a comparison between forecast results for a case comparable to the DOE/EIA's *AEO* Reference Case and forecasts for policy cases incorporating each of the trial standard levels. The analysis uses a variant of DOE's NEMS, known as NEMS-BT, to provide key inputs to the analysis and generate the impacts on the electric utility industry from trial standard levels. It compares NEMS-BT results for the base case and for policy cases in which proposed standards are in place. The results of the analysis consist of forecasted differences between the base and standards cases for electricity generation, installed capacity, sales, and prices.

In the analysis of specific standards, the default NEMS system load shape may be substituted with one that represents weather conditions for a typical meteorological year, to ensure that the system load shapes in NEMS are consistent with the end-use load shapes used to represent any reduction in energy demand related to the appliance or equipment being analyzed.

The utility analysis uses the assumptions of the most recent *AEO*, and treats efficiency standards as variations in policy. The effect of the policy is calculated as the difference between the Reference Case and the proposed standard case. The analysis also considers the high and low economic growth cases of *AEO*.

Regulatory Impact Analysis: To mitigate the overlapping effects on manufacturers of new or revised DOE energy-efficiency standards, this analysis identifies other regulatory actions affecting a product. Through manufacturer interviews and literature searches, the analysis compiles information on burdens from existing and impending regulations affecting the product. The analysis also includes a quantitative analysis of alternatives to amended energy conservation standards (e.g., rebates, consumer tax incentives, and early replacement incentives), using the NES Spreadsheet Model to calculate the NES and the NPV corresponding to specified alternatives to the amended energy conservation standards.

9. Technical Work Plan:
Environmental Assessment: The project work plan for conducting the Environmental Assessment consists of the following elements:

- Obtain the most recent version of NEMS from EIA.
- Install NEMS.
- Compare the output from the installed model to the results from the *AEO*. Proper installation of NEMS yields identical output to the results from the *AEO*.
- Analyze system and appliance end-use load shapes in NEMS to ensure that the proper coincidence between system load and appliance load is being modeled. To analyze NEMS' system and appliance end-use load shapes, the following tasks are performed:
    - *Appliance End-Use Load Data:* From the LCC analysis, generate appliance end-use load shapes. Compare the appliance end-use load shapes from the LCC analysis to those in NEMS for each of its sub-regions to determine if there are significant differences between the two sets of appliance end-use load shapes. (Note: There are 13 sub-regions within NEMS that are called Electricity Market Module (EMM) regions.)
    - *System Load Data:* Collect historical system load data from Federal Energy Regulatory Commission (FERC) Form 714 filings and aggregate data into 13 EMM regions. Using the historical system load data, generate TMY system load data by modeling the correlation between weather and system load. Compare the NEMS, historical, and TMY system load data to determine if there are significant differences between the three sets of load data.
    - *Compare Appliance and System Load Data for Coincidence:* For each NEMS EMM region, compare the coincidence of the NEMS, historical, and TMY system loads to the NEMS and LCC analysis appliance end-use loads. Determine which pairing of system and appliance loads best captures the actual coincidence between the system and appliance load.
    - *Replace NEMS Appliance End-Use and System Load Data:* If the NEMS system and appliance end-use load data do not best capture the coincidence between system and appliance loads, replace the NEMS data with the appropriate data.
- Input the national energy savings for each trial standard level (as generated by the National Impact Analysis) into NEMS.

- Run NEMS to generate the air-borne emission reductions from power plants due to appliance trial standard levels.
- For fossil-fuel-fired appliances, determine site emission factors from the literature. Calculate site air-borne emission reductions by using the site emission factors and the site energy savings associated with each trial standard level.

Employment Impact Analysis: The project work plan for conducting the Employment Impact Analysis consists of the following elements:

- Obtain IMBUILD from the Pacific Northwest National Laboratory (PNNL), the authors of IMBUILD.
- Install IMBUILD.
- Working with IMBUILD's authors, review the output from the installed model for accuracy.
- Working with IMBUILD's authors, review and modify approximately 50 inputs to the model to ensure the expected energy and financial impacts on the national economy due to appliance standards are properly modeled.
- Input the national energy savings and the national purchase costs and operating cost savings for each trial standard level (as generated by the National Impact Analysis) into IMBUILD.
- Working with IMBUILD's authors, review the national employment impacts generated by IMBUILD to ensure reasonableness of the results.

Utility Impact Analysis: The project work plan for conducting the Utility Impact Analysis consists of the following elements:

- The work plan is the same as the Environmental Assessment except that NEMS is run to generate the reduction in installed generation (i.e., demand capacity) due to appliance trial standard levels.

Regulatory Impact Analysis: The project work plan for conducting the Regulatory Impact Analysis consists of the following elements:

- Identify policy alternatives to mandatory energy efficiency standards.
- Conduct literature search to assess the effects that the identified alternatives have on consumer purchase decisions (i.e., the increased implementation rate of more-efficient products due to the policy alternatives).
- Establish methodologies for modeling policy alternatives within Shipments and NES spreadsheet tools. (Note: All policy alternatives are based on the adoption of the proposed standard level.)
- Modify inputs with Shipments and NES spreadsheet tools to model policy alternatives.
- Generate national energy savings and NPV due to policy alternatives.

10. Technical Problems/Barriers:

Environmental Assessment and Utility Impact Analysis: The most significant barrier in conducting the Environmental Assessment and Utility Impact Analysis is the installation of NEMS. As noted earlier, NEMS is a public domain, multi-sectoral, partial equilibrium model of the U.S. energy sector. Each year, DOE/EIA uses NEMS to produce a baseline energy forecast for the U.S., the *AEO.* Because NEMS is such an immense model, on-site installation is not trivial. For example, there are now parts of NEMS that are written by private contractors to the EIA, thereby making this code proprietary. This proprietary code must be purchased and incorporated into the publicly available (i.e., free) code into a full working model. In addition, because the objective of the installation is to produce a working model that can replicate the results in the *AEO*, all output from the model must be carefully reviewed, i.e., all discrepancies between the installed model output and the *AEO* results must be eliminated.

The system and appliance end-use load shape data within NEMS is another problem. Past reviews have revealed significant errors in the end-use load shape data for some appliances. As a result, DOE/EIA conducted a complete review and overhaul of its end-use load shape data in 2002. Questions into the origin of its system load data have also prompted DOE/EIA to review the system load data in NEMS.

Finally, new methods for processing the impacts of appliance standards on system loads have had to be developed to maintain the proper coincidence between system and appliance loads. These new methods rely on the direct manipulation of the system load data in NEMS. Thus, conducting the Environmental Assessment and Utility Impact Analysis is not a simple process of inputting the national energy savings due to a trial standard level into NEMS, running the model, and generating the output. Rather, additional steps must be taken to ensure that system loads are decremented in the proper manner so as to produce reliable impacts on air-borne emissions and generation capacity due to appliance standards.

Employment Impact Analysis: As mentioned above, to conduct the Employment Impact Analysis with IMBUILD, approximately 50 inputs must be reviewed and modified to ensure that the impact of appliance standards on the national economy are properly modeled. Although the effort in reviewing and modifying these inputs is not necessarily a problem, it does require working closely with the model's authors to ensure that any changes to the inputs are done properly.

Regulatory Impact Analysis: The most significant problem to the Regulatory Impact Analysis is finding retrospective data to verify the national energy savings and NPV results due to policy alternatives to mandatory energy efficiency standards. Although the literature is quite extensive on the types of alternative programs that have been implemented by Federal and State government agencies and utilities, there have been no retrospective analyses conducted to verify the estimated benefits due to these alternative programs. Without such data, the national impacts of alternatives to mandatory standards will always be in question.

11. Status of Milestones:

For the standards rulemakings discussed here—distribution transformers (DT) and residential furnaces and boilers (FB)—Utility Impact, Environmental Assessment, Employment Impact, and Regulatory Impact Analyses were not conducted for each product's Advance Notice of Proposed Rulemaking (ANOPR). Both the DT and FB

ANOPRs were published on July 29, 2004. Based on DOE's Process Rule, Utility Impact, Environmental Assessment, Employment Impact, and Regulatory Impact Analyses are not conducted until the Notice of Proposed Rulemaking (NOPR) phase of the standards rulemaking.

According to the *Regulatory Agenda*, the NOPRs for DT and FB are both scheduled to be published in September, 2006. Prior to publishing the NOPRs, the *Regulatory Agenda* calls for TSDs to be reviewed by the Department by September, 2005. Because TSDs are required to be completed and reviewed by September, 2005, the Utility Impact, Environmental Assessment, Employment Impact, and Regulatory Impact analyses are scheduled to be conducted by July, 2005 for FB and August, 2005 for DT.

Since many of the inputs to the Utility Impact, Environmental Assessment, Employment Impact, and Regulatory Impact Analyses are developed by the Shipments and National Impact analyses, these four analyses cannot be completed until the Shipments and National Impact Analyses have been finished. The Shipments and National Impact analyses for DT and FB were completed in May, 2005, thereby allowing large portions of these four analyses to be completed in June, 2005. Because the Utility Impact Analysis and Environmental Assessment conduct sensitivities on the proposed standard level and the Regulatory Impact analysis is based on the analysis of policy alternatives for adopting the proposed standard, these three analyses cannot be completed until DOE selects a proposed standard. Because DOE's decision for selecting a proposed standard is scheduled for July, 2005, these analyses are scheduled to be completed in July, 2005 for FB and August, 2005 for DT.

12. Efficiency Improvement Metrics:
There are ten product classes of DT that are being analyzed, consisting of thirteen design lines. The ten product classes are divided into classes of liquid-type transformers, typically used by electric utilities, and dry-type transformers, which are typically used at commercial and industrial building sites. The energy descriptor for DT is *efficiency*, which measures the total energy losses at a design load of 50 percent for liquid-type transformers and 35 percent for dry-type transformers. The cost of achieving higher transformer efficiency varies significantly over the product classes. The purpose of the NES/NPV part of the national impact spreadsheet is to calculate some of the key quantities by which a candidate energy efficiency standard may be evaluated. Two such quantities are national source energy savings and NPV. Source energy is total energy saved (or reduction in losses) by transformers. NPV is a measure of the net benefit to consumers due to an energy-efficiency standard.

There are six product classes of FB that are being analyzed. The six product classes consist of three furnace classes and three boiler classes. The energy descriptor for FB is the *annual fuel utilization efficiency* (AFUE), which takes into account the fuel consumption over the entire year. For the most predominant product class, non-weatherized gas furnaces, the existing minimum efficiency level is 78% AFUE. The analysis for the ANOPR demonstrated that, for non-weatherized gas furnaces, an 81% AFUE standard would yield an estimated 1.1 quads of cumulative energy savings while providing $0.75 billion in cumulative consumer NPV at a 7 percent real discount rate. The changes made to the National Impact analysis as described above for the NOPR lowered the cumulative energy savings to 0.4 quads for non-weatherized gas furnaces while providing no cumulative consumer NPV.

The Environmental Assessments to be conducted for DT and FB will show the impact on power-plant CO_2 and NO_x emissions due to various trial standard levels. CO_2 impacts will be expressed in million metric tons (Mt) while NO_x impacts will be expressed in kilo metric tons (kt). Because FB is a fossil-fuel-fired appliance, on-site emission reductions will also be determined.

The Employment Impact Analyses to be conducted for DT and FB will show national employment impacts due to various trial standard levels. Net national employment impacts will be disaggregated into three categories: impacts due to increased appliance costs, impacts due to energy savings, and impacts due to decreased utility expenditures. Net employment impacts due to appliance standards are typically very small relative to total national employment.

The Utility Impact Analyses to be conducted for DT and FB will show the impact on the utility industry's installed generation capacity due to various trial standard levels. Reductions in installed generation capacity will be expressed in gigawatts (GW).

The Regulatory Impact Analyses to be conducted for DT and FB will analyze the following policy alternatives to mandatory energy efficiency standards: consumer rebates, consumer tax credits, manufacturer tax credits, voluntary energy-efficiency targets, early replacement incentives, and bulk government purchases. For FB, regional energy efficiency standards will also be analyzed. Results for each policy alternative will be expressed as national energy savings and consumer NPV.

13. Project Output:

Major Accomplishments:

For DT, the major accomplishments are the publication of the Technical Support Document and the Analytical Spreadsheets that accompanied the ANOPR:

- U.S. Department of Energy-Office of Energy Efficiency and Renewable Energy, *Technical Support Document: Energy Efficiency Program for Commercial and Industrial Equipment: Electrical Distribution Transformers*, July, 2004. Washington, DC. <http://www.eere.energy.gov/buildings/appliance_standards/commercial/dist_trans_tsd_061404.html>
- U.S. Department of Energy-Office of Energy Efficiency and Renewable Energy, ANOPR Analytical Spreadsheets, Life-Cycle Cost Calculations by Design Line, October, 2004. Washington, DC. <http://www.eere.energy.gov/buildings/appliance_standards/commercial/distribution_transformers_spreadsheets.html>

For FB, the major accomplishments are the publication of the Technical Support Document and the Analytical Spreadsheets that accompanied the ANOPR:

- U.S. Department of Energy-Office of Energy Efficiency and Renewable Energy, *Technical Support Document: Energy Efficiency Program for Consumer Products: Energy Conservation Standards for Residential Furnaces and Boilers*, September, 2004. Washington, DC.
  < http://www.eere.energy.gov/buildings/appliance_standards/residential/furnaces_boilers_1113_r.html>
- U.S. Department of Energy-Office of Energy Efficiency and Renewable Energy, Residential Furnaces and Boilers ANOPR Analytical Tools, October, 2004. Washington, DC.
  < http://www.eere.energy.gov/buildings/appliance_standards/residential/furnace_boiler_draft_analysis.html>

Bibliography:

Wong-Parodi, Gabrielle, Lekov, Alex, Dale, Larry. Natural Gas Prices Forecast Comparison-AEO vs. Natural Gas Markets, LBNL-55701

Dale, Larry, Millstein, Dev, Coughlin, Katie, Van Buskirk, Robert, Rosenquist, Gregory, Lekov, Alex, Bhuyan, Sanjib. An Analysis of Price Determination and Markups in the Air-Conditioning and Heating Equipment Industry, LBNL-52791

Lutz, James, Dunham-Whitehead, Camilla, Lekov, Alex, McMahon, James, "Modeling energy consumption of residential furnaces and boilers in U.S. homes", LBNL-53924, 02/01/2004

Biermayer, Peter, Lutz, James, Lekov, Alex, Measurement of airflow in residential furnaces, LBNL-53947, 01/24/2004

Lutz, James, Lekov, Alex, Dunham-Whitehead, Camilla, Chan, Peter, Meyers, Steve, McMahon, James, Life-cycle cost analysis of energy efficiency design options for residential furnaces and boilers, LBNL-53950, 01/20/2004

14. Budget: N/A

15. Principal Project Personnel:

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- *Role in the project*: Principal Investigator
- *Principal areas of research and expertise*: Identify the feasibility and cost of engineering design changes that could increase energy efficiency for more than 20 specific products, analyze scenarios and economic impacts associated with adoption of these technologies, and assess potential impacts on key market actors, including consumers, manufacturers, utility companies, the nation, and the environment.
- *Percentage of time devoted to the project*: 2%
- *Education*: B.S., Chemistry (Providence College); Ph.D., Molecular Biophysics (Florida State University).
- *Relevant professional employment history*: LBNL, Environmental Energy Technologies Division (1978-present) – currently Head of the Energy Analysis Department, Leader of the Energy Efficiency Standards (EES) Group, and Co-chair of the Water Energy Technology Team (WETT) in the Environmental Energy Technology Division.

- *Relevant professional activities and honors*: American Association for the Advancement of Science, International Association for Energy Economics, co-Chair of American Council for an Energy-Efficient Economy (ACEEE) Summer Study on Buildings (2002).
- *Relevant publications not emanating from this project*: More than 50 publications, including:

  Rosenquist, Greg, Michael McNeil, Maithili Iyer, Steve, Meyers, and James McMahon. 2004. Energy Efficiency Standards for Residential and Commercial Equipment: Additional Opportunities. Berkeley, CA. Lawrence Berkeley National Laboratory.

  McMahon, James, Steve Meyers, Camilla Dunham Whitehead, Peter Chan, Alex Lekov, and James Lutz. 2004. Life-Cycle Cost Analysis of Energy Efficiency Design Options for Residential Furnaces and Boilers. Berkeley, CA. Lawrence Berkeley National Laboratory.

  Rosenquist, Greg, Katie Coughlin, Larry Dale, James McMahon, and Steve Meyers. 2004. Life-Cycle Cost and Payback Period Analysis for Commercial Unitary Air Conditioners. Berkeley, CA. Lawrence Berkeley National Laboratory.

  Lutz, James, Camilla Dunham Whitehead, Alex Lekov, James McMahon, 2004. Modeling Energy Consumption of Residential Furnaces and Boilers in U.S. Homes. Berkeley, CA. Lawrence Berkeley National Laboratory. 2004. LBNL-53924.

  McMahon, James and Stephen Wiel. 2003. Governments Should Implement Energy-Efficiency Standards and Labels - Cautiously. (31). 13. 1403-15. 2003.

  McMahon, James. 2003. New Analysis Techniques for Estimating Impacts of Federal Appliance Efficiency Standards. In Proceedings of the 3rd International Conference on Energy Efficiency in Domestic Appliances and Lighting; Turin, Italy, 1-3 October. (Part II). 927-934. 2003.

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- *Role in the project*: Project Manager, Residential Furnaces and Boilers
- *Principal areas of research and expertise*: Engineering and economic analysis with emphasis on energy calculations, test procedures, markups, life-cycle cost and national impact analysis; project management.
- *Percentage of time devoted to the project*: 6%
- *Education*: MS, Mechanical Engineering (Technical University, Sofia, Bulgaria, 1973), PhD, Mechanical Engineering (Polytechnic University, Prague, Chech Republic, 1981)
- *Relevant professional employment history:* National Renewable Energy Laboratory, researcher (1986-1990); Berkeley Solar Group, mechanical engineer/energy analyst (1991-1992); ADM Associates Inc., mechanical engineer/energy analyst (1992-2994); XENERGY Inc., mechanical engineer/energy analyst (1994-1996); LBNL, Program Manager (1996-present).

- *Relevant professional activities and honors:* Licenses: Professional Mechanical Engineer (P.E.) in California, Association of Energy Engineers Certified Energy Manager, American Gas Association Chartered Industrial Gas Consultant. Other activities: American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE), Member of Technical Committee on Service Water Heating, Member of ASHRAE SPC 103 Method of Testing for AFUE of Residential Central Furnaces and Boilers.
- *Relevant publications not emanating from this project*: Holder of six patents and author of more than 60 technical articles and reports, including:

Healy, William, James Lutz, Alex Lekov. 2003. “Variability in Energy Factor Test Results for Residential Electric Water Heaters”, HVAC & R Research, vol.9, No 4, October 2003.

Lekov, Alex, James Lutz, Xiaomin Liu, Camilla Dunham-Whitehead, and James McMahon. 2000. “Determining Benefits and Costs of Improved Water Heater Efficiencies” In Proceedings of the 35th Intersociety Energy Conversion Engineering Conference, Las Vegas, NV July 24-28, American Institute of Aeronautics and Astronautics, 2.1046-1052.

Lekov, Alex, Julie Glover, James Lutz. 2000. The LBNL Water Heater Retail Price Database, LBNL-44749, 10/01/2000.

Lekov, Alex, Alexander Penchev, and Genko Dimitrov. 1991. "New Architectural and Construction Decisions Using Passive Solar Systems", Journal of Building Materials, Bulgaria, Vol. X, Number 1.

Subbarao, Kris, Jay Burch, Doug Balcomb, Ed Hancock, and Alex Lekov. 1989. "Short-Term Energy Monitoring STEM-1.1 User Manual", SERI, TR-254-3613, December.

Lekov, Alex, Doug Balcomb, and Norm Weaver. 1988. "Development of an Expert System to Aid in the Design of Passive Solar Buildings", III Conference on Expert System Applications in Buildings, Tucson, AR, U.S.A.

Lekov, Alex and Doug Balcomb. 1987. "Energy Signatures: New Results," proceedings of the 12th International Passive Solar Conference, Portland, OR, U.S.A.

Lekov, Alex, Alexander Stamenov, Plamen Penkov. 1987. "Evaluation of the Efficiency of Air Solar Heater with Integrated Transparent Covering," Journal of Zdravotni Technika a Vzduchotechnika, Czechoslovakia, Number 6.

Lekov, Alex, Stephan Kanev, Plamen Penkov, Nikolai Zeckov. 1986. "Experimental Study of Fluidized Layer as an Absorber of Flat Plate Solar Collector," Sofia Polytechnics, Bulgaria, Vol. XXIII, Number 2.

Lekov, Alex. 1982. "Evaluation of the Efficiency of a Regenerative-type Heat Exchanger," Journal of Zdravotni Technika a Vzduchotechnika, Czechoslovakia, Number 4.

<u>Patents</u>

Lekov, Alex, reg. #40768/April 12,1985, "Air-to-air Heat Exchanger".

Lekov, Alex, etc., reg. #41603/February 05, 1986, "Thermal Storage Material for Regenerative Type Heat Exchangers".

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- *Role in the project*: Project Manager, Residential Furnaces and Boilers
- *Principal areas of research and expertise*: Appliance standards and testing, focusing on furnaces, water heaters, residential hot water distribution systems, and refrigerators
- *Percentage of time devoted to the project*: 1%
- *Education*: B.A. Sociology (Stanford University, 1979); B.S. Engineering Science, (California Polytechnic University, 1986).
- *Relevant professional employment history:* ADM Associates, Energy Engineer (1986-1987); Sun Up Design, Energy Consultant (1987); Berkeley Solar Group, Engineer (1987-1990); LBNL, Staff Research Associate (1990-present).
- *Relevant professional activities and honors:* Professional Licenses: Professional Engineer, Mechanical Engineering (California); General Building Contractor (California). American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE) Standards Committee; Chair of Standards Project Committee 118.2, Method of Testing for Rating Residential Water Heaters; Chair of Technical Committee 6.6, Service Water Heating Research Subcommittee; Voting Member of Technical Committee 6.6. Formerly Chair of Standards Project Committee 118.1, Method of Testing for Rating Commercial Gas, Electric and Oil Service Water Heating Equipment; Chair of the Project Monitoring Subcommittee of Research Project 1172, Metering Residential Hot Water By End Use; and voting member of Standards Project Committee 146P, Method of Testing for Rating Pool and Spa Heaters. Member of the American Society of Mechanical Engineers, the American Society of Plumbing Engineers, the American Solar Energy Society, and the American Water Works Association.
- *Relevant publications not emanating from this project*: More than 30 publications, including:

Healy, William; Lutz, James D.; Lekov, Alex, *Variability in Energy Factor Test Results for Residential Electric Water Heaters*, LBNL-51665, Vol. 9, No. 4, HVAC&R Research Journal, October 2003.

ASHRAE/ANSI Standard 118.1-2003, *Method of Testing for Rating Commercial Gas, Electric and Oil Service Water Heating Equipment*, June 2003.

Lutz J D., Whitehead C D., Lekov A B., Liu X. , and McMahon J.E., *A Monte Carlo Approach to the Calculation of Energy Consumption for Residential Gas-Fired Water Heaters*, ASHRAE Trans., 2000, Vol.106, Part 2, Paper number MN-00-15-03, LBNL-44829

Lekov A.B., Whitehead C D., Lutz J D., and McMahon J.E., *Cost of Increased Energy Efficiency for Residential Water Heaters*, ASHRAE Trans., 2000, Vol.106, Part 2, Paper number MN-00-15-02, LBNL-44830

Lutz J D., Lekov A B., and Whitehead C D., *Residential Water Heaters: The Impact of Regulatory Changes*, 51st Annual International Appliance Technical Conference, Lexington, KY, May 2000, LBNL-44831

Lutz J D., *Demonstrating Economic Justification - Updating Water Heater Efficiency Standards,* Proceedings of the 2000 ACEEE Summer Study on Energy Efficiency in Buildings, Asilomar, CA, August 2000, LBNL-45829

Chaitkin S.D., Whitehead C D., Van Buskirk R.D., Lutz J D., and McMahon J.E. *Estimating Marginal Residential Energy Prices in the Analysis of Proposed Appliance Energy Efficiency Standards*, Proceedings of the 2000 ACEEE Summer Study on Energy Efficiency in Buildings, Asilomar, CA, August 2000, LBNL-44230

Lekov A B., Lutz J D., Whitehead C D., and McMahon J.E., *Payback Analysis of Design Options for Residential Water Heaters,* 2000 ACEEE Summer Study on Energy Efficiency in Buildings, Asilomar, CA, August 2000, LBNL-45312

Lekov A B., Lutz J D., Liu X., Whitehead C D., and McMahon J.E., *Determining Benefits and Costs of Improved WH Efficiencies,* 35th Intersociety Energy Conversion Engineering Conference, Las Vegas, NV, July 2000, LBNL-45618

Dr. John Stoops, Lawrence Berkeley National Laboratory (LBNL), 1 Cyclotron Road, MS-90R4000, Berkeley, CA 94720-8136, Tel: 510-486-6114, Fax: 510-486-6996, Email: JLStoops@lbl.gov.

- *Role in the project*: Project Manager, Distribution Transformers
- *Principal areas of research and expertise*: Economic and engineering analysis of energy efficiency in buildings and equipment, large-scale field instrumentation and data analysis, thermal comfort
- *Percentage of time devoted to the project*: 6%
- *Education*: BA, Mathematics/Economics (Whitman College); MBA, Finance (University of Washington); Licentiate, Building Services Engineering, and PhD, Building Services Engineering (Chalmers University of Technology, Gothenburg Sweden).
- *Relevant professional employment history:* Pacific Northwest National Laboratory, Research Scientist, Program Manager, Group Leader (1975-1998); Chalmers University of Technology, Guest Researcher (1998-2001); Lawrence Berkeley National Laboratory, Program Manager (2001-present).
- *Relevant professional activities and honors:* Involvement with ASHRAE.
- *Relevant publications not emanating from this project*:

Stoops, J. L. 1998. "Managing the Practical Challenges in Large End-Use Metering Projects." For *Improving Electricity Efficiency in Commercial Buildings*. 21-23 September 1998 Amsterdam, The Netherlands.

Stoops, J. L., and M. H. Sherman, 1994. Co-editors - Proceedings of the American Council for an Energy Efficient Economy 1994 Summer Study on Energy Efficiency in Buildings, Volumes 1 - 10. August 23 – September 3, 1994, Pacific Grove, California. American Council for an Energy-Efficient Economy (ACEEE), Washington, D.C.

Halverson, M. A., J. L. Stoops, J. R. Schmelzer, W. D. Chvala, J. M. Keller, and L. Harris. 1994. "Lighting Retrofit Monitoring for the Federal Sector –

Strategies and Results at the DOE Forrestal Building." In Proceedings of the American Council for an Energy Efficient Economy 1994 Summer Study on Energy Efficiency in Buildings, Vol. 2, pp 2.137-2.144. August 23 – September 3, 1994, Pacific Grove, California. American Council for an Energy-Efficient Economy (ACEEE), Washington, D.C.

Stoops, J. L., et al. 1991. "Building Energy Monitoring." Chapter 37 in *1992 HVAC Applications - ASHRAE Handbook*, ed. R. A. Parsons, pp. 37.1-37.14. American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc., Atlanta, Georgia.

Stoops, J. L. 1990. "End-Use Profile Development From Whole Building Data Combined With Intensive Short Term Monitoring." For *Innovative Monitoring Approaches in Buildings*. June 22-26, 1991, Indianapolis, Indiana.

Stoops, J. L., and R. G. Pratt. 1990. "Empirical Data for Uncertainty Reduction." For *ACEEE 1990 Summer Study*. August 26 - September 1, 1990, Pacific Grove, California.

Conner, C. C., J. L. Stoops, and M. A. Halverson. 1990. "The Practical Challenges of Converting End-Use Data Into Information." In *End-Use Load Information and Its Role in DSM*, pp. (session one, projects). July 11-13, 1990, Irvine, California.

Dr. Maithili Iyer, Lawrence Berkeley National Laboratory (LBNL), 1 Cyclotron Road, MS-90R4000, Berkeley, CA 94720-8136, Tel: 510-486-5187, Fax: 510-486-6996, Email: MIyer@lbl.gov.

- *Role in the project*: Assists in Utility, Environmental, Regulatory Impact, and Employment impact analyses for standards rulemakings.
- *Principal areas of research and expertise*: Quantitative data, market and policy analysis; energy efficiency policy and programs and economic evaluation of technologies and technology transfer; community participation and development issues related to environmental policy; policy issues in global climate change, renewable energy and the environment.
- *Percentage of time devoted to the project*: 1%
- *Education*: B.Sc, Mathematical Statistics (University of Delhi, India, 1988); M.Sc, Operations Research -- Decision Sciences (University of Delhi, India, 1990); Ph.D., Urban Affairs and Public Policy (University of Delaware, 1999)
- *Relevant professional employment history:* The Energy and Resources Institute (TERI), New Delhi, India, Research Associate (1991–1994); Center for Energy and Environmental Policy, University of Delaware, Research Associate (1994–1996); College of Marine Studies, University of Delaware, Program Analyst (1997-1998); Institute for Global Environmental Strategies (IGES), Japan, Visiting Research Fellow (1998-1999); LBNL, Principal Research Associate (2000 - present).
- *Relevant publications not emanating from this project*:

Jiang, Lin and Maithili Iyer. 2005 (forthcoming). "Cold or Hot Wash: How technological choices lead to cultural change and potential increase in clothes washing energy use in China." In Proceedings of 2005 Summer

Study on Energy Savings: What Works & Who Delivers? Paris, France: European council for an energy efficient economy.

Derringer, Joseph, Maithili Iyer, and Joe Huang. 2004. "Transferred just on paper? Why doesn't the reality of Transferring/Adapting Energy Efficiency Codes and Standards come close to the potential?" In Proceedings of 2004 ACEEE Summer Study on Energy Efficiency in Buildings Washington, DC: American Council for an Energy-Efficient Economy.

Moezzi, Mithra and Maithili Iyer. 2002. "What is Transferred Along with Energy Efficiency?" In Proceedings of 2002 ACEEE Summer Study on Energy Efficiency in Buildings Washington, DC: American Council for an Energy-Efficient Economy.

Iyer, Maithili, Willett Kempton, and Chris Payne. 1998. "Comparison Groups as a tool for evaluating energy efficiency programs: An analysis of ENERGY STAR Billing comparison groups." In Proceedings of 1998 ACEEE Summer Study on Energy Efficiency in Buildings. Washington, DC: American Council for an Energy-Efficient Economy

Lord, Deirdre, Willett Kempton, Sam Rashkin, Annette Wilson, Christine Egan, Anita Eide, Maithili Iyer, and Christopher Payne. 1996. "Energy Star Billing: Innovative Billing Options for the Residential Sector" In Proceedings of 1996 ACEEE Summer Study on Energy Efficiency in Buildings. Washington, DC: American Council for an Energy-Efficient Economy.

Dr. Robert Van Buskirk, Lawrence Berkeley National Laboratory (LBNL), 1 Cyclotron Road, MS-90R4000, Berkeley, CA 94720-8136, Tel: 510-495-2310, Fax: 510-486-6996, Email: RDVanBuskirk@lbl.gov.

- *Role in the project*: Chief Analyst
- *Principal areas of research and expertise*: Planning, development, and production of energy and energy efficiency policy analysis. Development of policy analysis models, software, and spreadsheet tools. Applications include the economic feasibility analysis of appliance, efficiency standards and programs in the U.S. and internationally. Supervision of research in the economics of policy impacts, costs and benefits. Development of integrated economic, meteorological, and air quality models for air quality policy analysis.
- *Percentage of time devoted to the project*: 1%
- *Education*: B.A., Physics & Mathematics (Univ. of California, Berkeley, 1984); M.A., Physics (Harvard University, 1986); Ph.D., Physics (Harvard University, 1991).
- *Relevant professional employment history:* Natural Resources Consulting Engineers, Modeling Specialist (1991-1993); University of Asmara, Eritrea, Assistant Professor/Fulbright Scholar (1993-1996); Eritrea Technical Exchange, System Administrator/Developer (1995-1997); Eritrea Department of Energy, Senior Research Scientist (1995-1997); Calmar Online Communications Ltd., Hong Kong/Beijing, Technical Project Manager (1997-1998); San Jose State University, Adjunct Professor (1997-1999); LBNL, Principal Research Associate

(1999-2000); Santa Clara University, Adjunct Professor (2004-present); Department of Meteorology, San Jose State University, Adjunct Professor (2002-present); LBNL, Scientist (2000-present).

- *Relevant professional activities and honors:* Lab Director's Research Development grant: "Evaluation of dyanamic air quality impacts of distributed generation," October 2002; Outstanding Performance Award, Lawrence Berkeley National Laboratory, October 2001; J. William Fulbright Lecturer Award, September 1993 - September 1994.
- *Relevant publications not emanating from this project*:

Dale, Larry, Dey Millstein, Katie Coughlin, Robert Van Buskirk, Greg Rosenquist, Alex Lekov, Sanjib Bhuyan. 2004. "An Analysis of Price Determination and Markups in the Air-Conditioning and Heating Equipment Industry." LBNL-5279.

Coughlin, Katie and Robert Van Buskirk. 2002. Efficiency policy analysis with temporally and regionally varying energy costs. IEECB-RL5 Conference, May 28-31, 2002, Nice, FRANCE.

Van Buskirk, Robert and Katie Coughlin. 2002. Measuring National and Regional Trends and Transformations in Electricity Use, Efficiency, and Conservation. IEECB-RL5 Conference, May 28-31, 2002, Nice, FRANCE.

Rosenquist, Greg, P. Chan, A. Lekov, J. McMahon, and R. Van Buskirk. 2002. "Consumer Life-Cycle Impacts of Energy Efficiency Standards for Residential-Type Central Air Conditioners and Heat Pumps," ASHRAE Winter Meeting, January 12-16, 2002, Atlantic City, New Jersey, U.S.A.

Coughlin, Katie and Robert Van Buskirk. 2001. "Boom/Bust Cycles in Electricity Infrastructure Development," EPRI 13-th Forecasting Symposium: Price and Load Forecasting in Volatile Energy Markets, November 13-15, 2001, Nashville, TN.

Van Buskirk, R., K. Coughlin, and E. Rendek. 2001. "Modeling Price-Load Relationships in Electricity Markets," EPRI 13-th Forecasting Symposium: Price and Load Forecasting in Volatile Energy Markets, November 13-15, 2001, Nashville, TN.

Van Buskirk, Robert. 2000. "Econometric modeling of the effects of energy efficiency standards on appliance shipments," In Proceedings 2000 ACEEE Summer Study on Energy Efficiency in Buildings, 9.371, American Council for an Energy-Efficient Economy, Washington D.C.

Chaitkin, S., G. Rosenquist, C. Dunham Whitehead, R. Van Buskirk, and J.E. McMahon. 2000. Estimating and applying marginal energy prices in the analysis of proposed appliance energy efficiency standards in the residential sector, submitted to the 2000 ACEEE Summer Study on Energy Efficiency in Buildings.

Dr. Larry Dale, Lawrence Berkeley National Laboratory (LBNL), 1 Cyclotron Road, MS-90R4000, Berkeley, CA 94720-8136, Tel: 510- 495-2477, Fax: 510-486-6996, Email: LLDale@lbl.gov.

- *Role in the project*: Economist/scientist: Estimate distribution markups, discount rates, and employment impacts, and research tax impacts on LCC results, appropriate LCC procedures, and price impacts of efficiency standards.
- *Principal areas of research and expertise*: Water energy economics, energy economics, and energy market and pricing.
- *Percentage of time devoted to the project*: 16%
- *Education*: Ph.D., Agricultural Economics (University of Hawaii, 1990); M.S., Agricultural Economics (University of California, Davis); B.A., Economics (University of California, Davis).
- *Relevant professional employment history:* Forest and Range Experiment Station, Economist (1979-1982); East West Center, Fellow (1983-1987); University of Santa Clara, Professor, Consultant (1995-2002); LBNL, Economist/Scientist (2001-present).
- *Relevant publications not emanating from this project*:

Hayhoe, Katharine, Larry Dale, et al. 2004. “Emissions Pathways, Climate Change, and Impacts on California,” in *Proceedings of the National Academy of Sciences*. August 16, 2004.

Dale, Larry, C.D. Whitehead, and N. Williams. 2003. “Trends in the Adoption of Residential Water Meters in California” in *Advances in Water Supply Management.* Cedo Maksimovic and David Butler. September 2003, Palkema Publishers.

Paper presented at the Computer and Control in the Water Industry (CCWI) Conference in London, August 2003.

Dale, Larry, K.Coughlin, G.Rosenquist, A.Lekov and D. Millstein. 2003. “Markups for Equipment Price Determination.” June 2003. LBNL-52791.

Sathaye, Jayant, Willy Makundi and Larry Dale. 2003. Estimating Forestry Climate Mitigation Potential and Costs: A Partial Equilibrium Approach and Indonesia Case Study. Presented at the Energy Modeling Forum (EMF 21). March 2003. *Energy Journal*. Accepted 2005.

Dale, Larry, Camilla Dunham Whitehead, and Andre Fargeix. 2003. “Electricity Price and Southern California’s Water Supply Options.” *Resources, Conservation and Recycling*, March 2004.

Dale, Larry, Camille Antinori, Michael McNeil and Jim McMahon. 2003. “Retrospective evaluation of declining prices for energy efficiency appliances.” In *Energy Efficiency in Domestic Appliances and Lighting (EEDAL’03) conference proceedings.* September 2003.

Dale, Larry and Michael Roberts. 2005. “Discount rates applied to energy conservation projects.” June 2005. LBNL-50442.

Dale, Larry. 2003. “The Benefits of Appliance Efficiency Standards to Landlords and Tenants.” Draft work. June 2003. LBNL – 53070.

Rosenquist, Greg, Katie Coughlin, Larry Dale, James McMahon and Steve Meyers. 2004. Life-cycle Cost and Payback Period Analysis for Commercial Unitary Air Conditioners. March 2004. LBNL-54244.

16. Other Information Sources:

More information on the project can be found on the following websites:

- http://www.eere.energy.gov/buildings/appliance_standards/residential/furnaces_boilers.html
- http://www.eere.energy.gov/buildings/appliance_standards/commercial/distribution_transformers.html
- http://eappc76.lbl.gov/tmacal/ees.cfm

SLIDE PRESENTATIONS ON JUNE 28 & 29, 2005

U.S. Department of Energy
Energy Efficiency and Renewable Energy

U.S. Department of Energy
Appliance Standards Program

Peer Review

BRYAN BERRINGER
June 28 & 29, 2005

1

Rulemaking Background

- Long Standing Program
  - EPCA, Requires appliance standards to be set in 1975
  - NAECA, Amended EPCA in 1987 to include covered products
  - NAECA, Amended in 1988 to add ballast
  - EPACT, Amended EPCA in 1992 to include industrial equipment

- Process Improvement
  - July 15, 1996, Established a open process with stakeholders
  - Priority setting process established

- Nation Energy Policy (NEP)
  - Supports existing appliance standards
  - Setting higher standards that are technologically feasible and economically justified
  - Expanding scope of the program

2

U.S. Department of Energy
Energy Efficiency and Renewable Energy

Components

- Energy Efficiency Standards
  - Advance Notice of Proposed Rulemaking
  - Notice of Proposed Rulemaking
  - Final Rule
- Test Procedures
  - Notice of Proposed Rulemaking
  - Final Rule
- Labels
- Waivers

3

U.S. Department of Energy
Energy Efficiency and Renewable Energy

Legislated Requirements: Seven factors

- ✓ The economic impact of the standard on the manufacturers and on the consumers of the products;
- ✓ The savings in operating costs throughout the estimated average life of the product compared to any increase in the price or maintenance expenses of the product;
- ✓ The total projected amount of energy savings likely to result from the standard;
- ✓ Any lessening of the utility or performance of the product;
- ✓ The impact of any lessening of competition as determined by the Attorney General;
- ✓ The need of the nation to save energy; and
- ✓ Other factors considered relevant.

4

U.S. Department of Energy
Energy Efficiency and Renewable Energy

Rulemaking Background

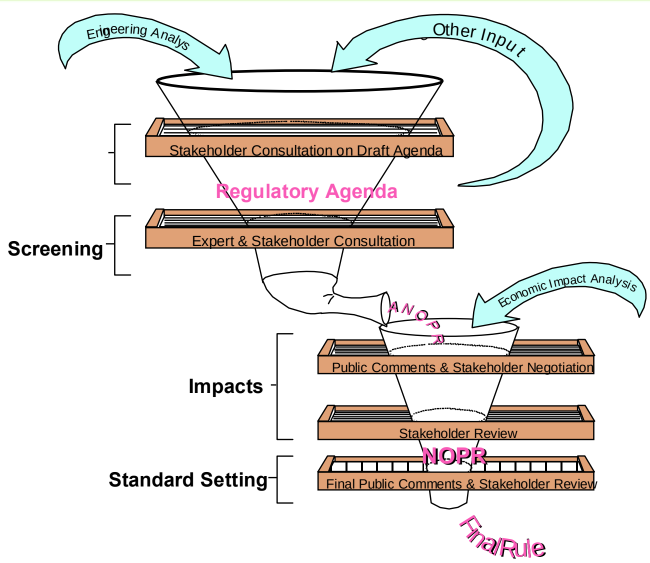
Benefits of Appliance Standards Program:

Appliance	Energy Savings (Quads)	NPV Savings ($ Bil.)	Water Savings (tril gals)	NOx (kt)	Carbon Equiv. (Mt)
				Benefits – Cumulative	
Refrigerators and Freezers (NAECA)	6.1	17.82			
Refrigerators and Freezers (First update)	5.2	9.1			
Refrigerators and Freezers (Second update)	6.67			1362	126.8
Room Air Conditioners (NAECA)	1.22	2.46			
Room Air Conditioners (First update)	0.64	0.51		95	14.7
Central Air Conditioners (NAECA)	4.3	7.89			
Central Air Conditioners (First update)	3.0	2.0		73	24
Clothes Dryers (First update)	0.82	1.3		196	17.9
Clothes Washers (First update)	0.57	0.53	0.006	107.8	11.7
Clothes Washers (Second update)	5.52	15.3	11.59	253.5	95.1
Dishwashers (First update)	6.29	0.43	0.24	173	17.9
Water Heaters (NAECA)	3.39	10.02			
Water Heaters (First Update)	4.6	2.0		273.0	152
Gas Furnaces (NAECA)	8.04	8.31			
Flourescent Lamp Ballasts (First Updates)	1.2 - 2.3	2.4 -3.9		34 - 60	11 - 19

5

U.S. Department of Energy
Energy Efficiency and Renewable Energy

Rulemaking Process



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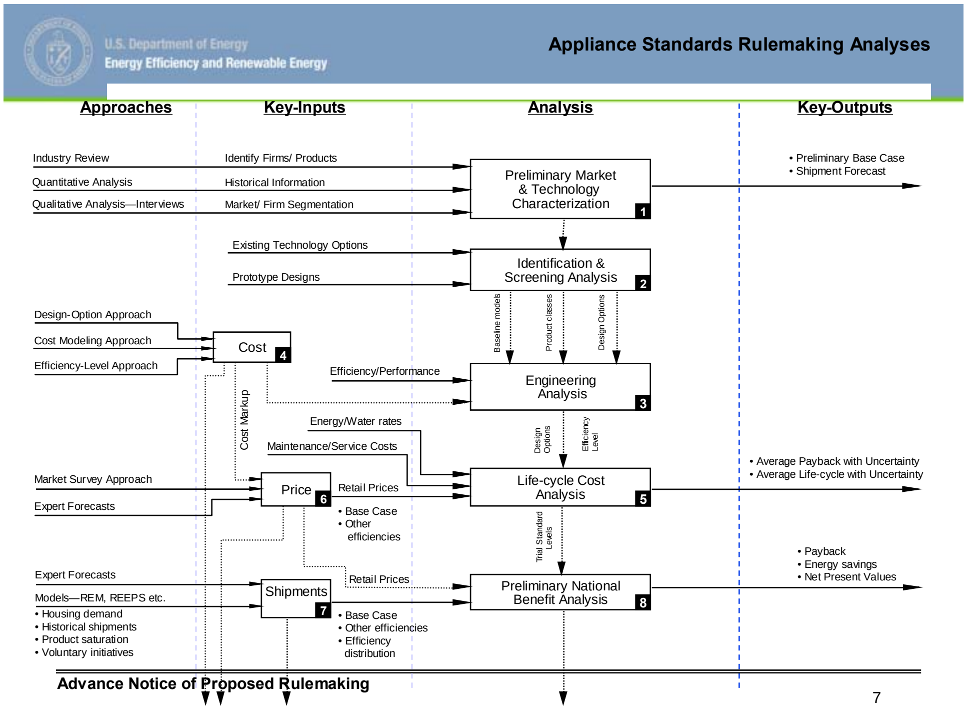

U.S. Department of Energy
Energy Efficiency and Renewable Energy
Appliance Standards Rulemaking Analyses
Approaches
Key-Inputs
Analysis
Key-Outputs
Industry Review
Quantitative Analysis
Qualitative Analysis—Interviews
Identify Firms/ Products
Historical Information
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• Shipment Forecast
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Baseline models
Product classes
Design Options
Design-Option Approach
Cost Modeling Approach
Efficiency-Level Approach
Cost 4
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Engineering Analysis 3
Cost Markup
Energy/Water rates
Maintenance/Service Costs
Design Options
Efficiency Level
Market Survey Approach
Expert Forecasts
Price 6
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• Average Life-cycle with Uncertainty
• Base Case
• Other efficiencies
Trial Standard Levels
Expert Forecasts
Models—REM, REEPS etc.
• Housing demand
• Historical shipments
• Product saturation
• Voluntary initiatives
Shipments 7
Retail Prices
Preliminary National Benefit Analysis 8
• Payback
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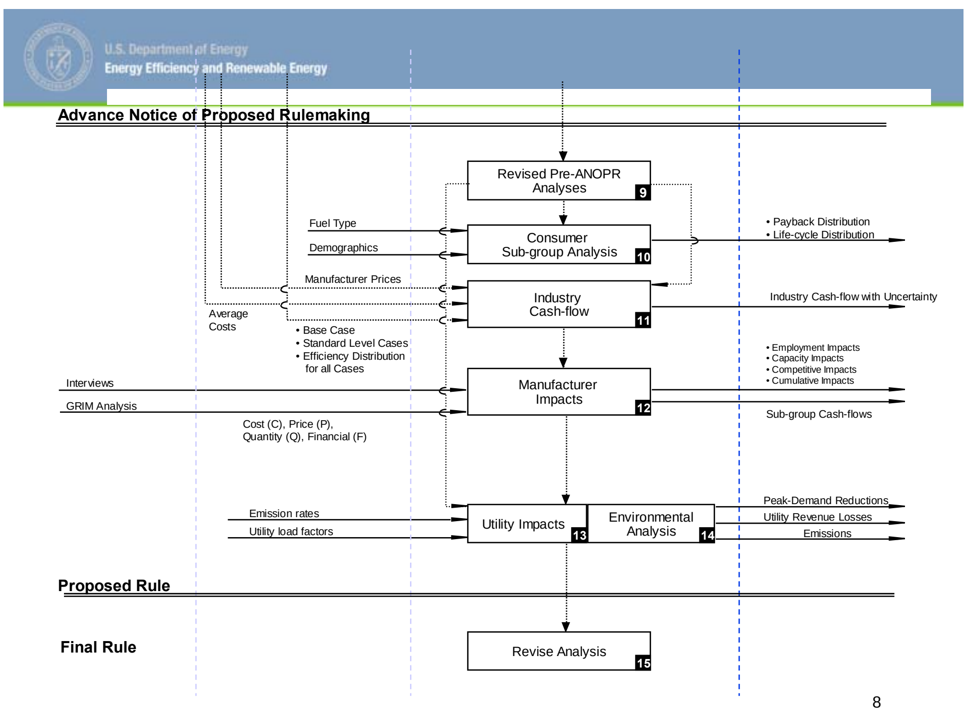
• Net Present Values
• Base Case
• Other efficiencies
• Efficiency distribution
Advance Notice of Proposed Rulemaking
7



U.S. Department of Energy
Energy Efficiency and Renewable Energy
Advance Notice of Proposed Rulemaking
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• Capacity Impacts
• Competitive Impacts
• Cumulative Impacts
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Cost (C), Price (P), Quantity (Q), Financial (F)
Emission rates
Utility load factors
Utility Impacts 13
Environmental Analysis 14
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Emissions
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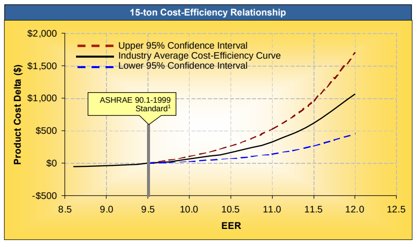
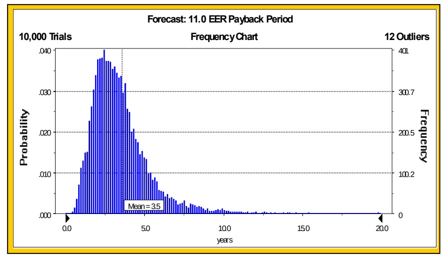
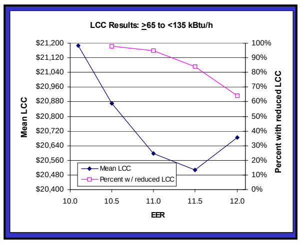
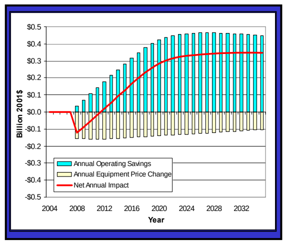
Final Rule
Revise Analysis 15
8

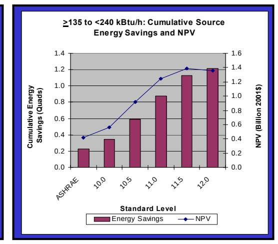
Appliance Standards Rulemaking Analyses





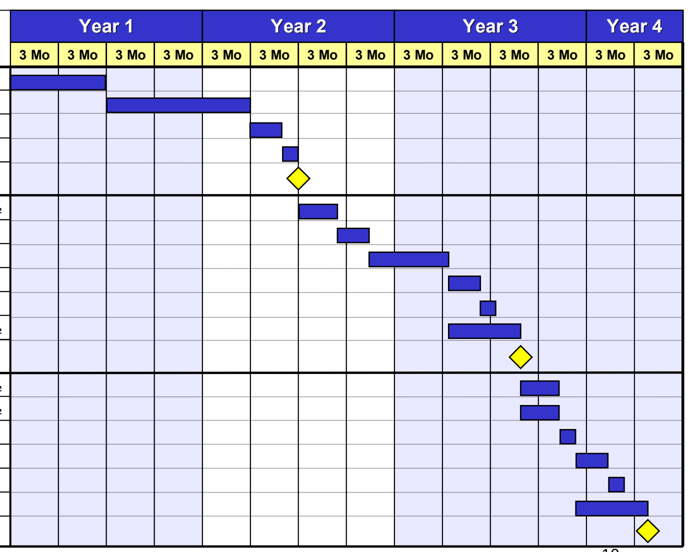






Appliance Standards Rulemaking Timeline

		Months
ANOPR	• Framework Document	6
	• Perform Analysis	9
	• Mandatory Concurrence	2
	• Secretary's Review	1
	• Publish ANOPR	**18**
NOPR	• Comment Period	2 ½
	• Revise ANOPR Analysis	2
	• Additional Analysis	5
	• Mandatory Concurrence	2
	• Secretary's Review	1
	• OMB Review	4 ½
	• Publish NOPR	**14**
Final Rule	• DOJ NOPR Review	2 ½
	• Comment Period	2 ½
	• Revise NOPR Analysis	1
	• Mandatory Concurrence	2
	• Secretary's Review	1
	• OMB Review	4 ½
	• Publish Final Rule	**8**



U.S. Department of Energy
Energy Efficiency and Renewable Energy

Priority Setting

Standards		Test Procedures	
Commercial Air-Cooled Central Air-Conditioners and Air-Source Heat Pumps, 65-240 kBtu/hr		Distribution Transformers	
Distribution Transformers		Residential Central Air-Conditioners and Heat Pumps (including Small Duct High Velocity)	
Residential Furnaces and Boilers			
Commercial Air-Cooled Central Air-Conditioners and Heat Pumps, 3-phase, <65 kBtu/hr			
Commercial Oil- and Gas-Fired Packaged Boilers			
Packaged Terminal Air-Conditioners and Heat Pumps			
Single-Packaged Vertical Units			
Tankless Gas-Fired Instantaneous Water Heaters			

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U.S. Department of Energy
Energy Efficiency and Renewable Energy

Priority Setting

Appliance Standards Program: The Memorandum Announcing the Proposed Fiscal Year (FY) 2005 Priorities for the Appliance Standards Rulemaking Process, and the "FY2005 Preliminary Priority-Setting Summary Report and Actions Proposed" are available on the DOE website at:

http://www.eere.energy.gov/buildings/appliance_standards/priority_setting.html

12

U.S. Department of Energy
Energy Efficiency and Renewable Energy

Building Technologies Program Project-Level Peer Review

John D. Ryan
June 28, 2005

U.S. Department of Energy
Energy Efficiency and Renewable Energy

Peer Review Scope – BT '05

- Focus on individual projects
- Not designed to evaluate the overall BT program or its subprograms in a holistic manner
- All current projects under BT management control (R&D, deployment, and analysis projects)
- Entire project life cycle – both completed work and planned future work

U.S. Department of Energy
Energy Efficiency and Renewable Energy

Peer Review Scope – BT '05

- Projects: 150+
- Expert Panels: approx. 12
- Reviewers: approx. 90
- Jan. – Oct. 2005

U.S. Department of Energy
Energy Efficiency and Renewable Energy

How Will Peer Review Results be Used?

- Assist Managers to:
  - continue, modify, or redirect individual projects
  - adjust program portfolios
  - assess overall program performance and productivity
  - identify closures or areas where further study is desirable
- Provide input for the FY07 planning process

U.S. Department of Energy
Energy Efficiency and Renewable Energy

Reporting Requirements

- ARCHIVAL REPORT
  - An **internal** report fully documenting all aspects of the review
- PROJECT REPORT
  - An **informal** report to Principal Investigators summarizing reviewer comments on his/her project.
- EXECUTIVE SUMMARY
  - A **publicly releasable** report summarizing the projects, process and aggregated, program-level results
- IMPLEMENTATION PLAN
  - An **internal** report assessing the results and providing an action plan to implement needed improvements

U.S. Department of Energy
Energy Efficiency and Renewable Energy

Evaluation Criteria

- Approach
- Accomplishments
- Productivity
- Relevance
- Overall Assessment

U.S. Department of Energy
Energy Efficiency and Renewable Energy

Typical Project Session

- PI Oral Presentation – 30 Minutes
- Q&A from Panelists – 20 Minutes
- Fill out Evaluation Forms – 20 Minutes

Time schedule will be closely followed.

U.S. Department of Energy
Energy Efficiency and Renewable Energy

Guidelines for Project Session

- PI Oral Presentation:
  - Minimize interruptions of PI presentation
- Q&A:
  - Purpose: Obtain additional insights & data from PI
  - Minimize discussion among panel members
  - Adopt appropriate style for limited time available
- Fill out Evaluation Forms:
  - Panel discussion encouraged
  - Allow some quiet time for deliberation and recording evaluation results.

Guidelines for Evaluation

- Ratings
  - Discriminate among projects
  - **<u>Comments are vital</u>** – basis for rating & action
- Consensus
  - Consensus is not desired – individual inputs are valued
  - Panel discussion is encouraged to share viewpoints & other data
- Evaluation Forms
  - Goal is to complete process by the end of the meeting
  - Timely comments afterward will be accepted.

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Final Session

- Finalize Project Evaluation Forms
- Fill out Evaluation of Overall BT Peer Review Process
- Discuss Programmatic Items and Record Input

Programmatic Input

Review of individual projects may stimulate insight at a higher level. These insights are valued and should be captured separately from project evaluations. Examples include:

- Portfolio
  - Balance among projects
  - Additional topics or approaches for research
- Budgets
  - Insights on more efficient ways of doing business
  - BT operates in a very constrained budget environment, pleas for higher investment in the area are not particularly helpful
- Objectives
  - Insights on selecting objectives (decision processes)

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U.S. DOE Energy Conservation Standards

Screening and Engineering Analyses

Principal investigator
Michael C. Rivest
Navigant Consulting, Inc.

June 28, 2005

U.S. Department of Energy
Energy Efficiency and Renewable Energy

Agenda

This presentation is organized into the following key areas:

1. Objectives and Strategic Relevance
2. Technical Approach
3. Resources and Schedules
4. Results

2

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1. Objectives and Strategic Relevance
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This project is designed to satisfy the legislative mandate for DOE to analyze appliance efficiency standards.

» The Energy Policy and Conservation Act (EPCA) provides criteria for prescribing new or amended standards which will achieve the maximum improvement in energy efficiency, which the Secretary of Energy determines is technologically feasible and economically justified, and establishes guidelines for determining whether a standard is economically justified. 42 U.S.C. 6313(a)(6)(A).

» The Screening Analysis seeks to eliminate problematic design options early in the process of revising an energy efficiency standard. Under the guidelines, DOE only considers design options that are feasible and practical.

» The Engineering Analysis develops cost-efficiency relationships, estimating manufacturer costs of achieving increased efficiency levels. Manufacturing costs are used as the basis for determining retail prices in the Life-Cycle Cost (LCC) Analysis, and are needed for the Manufacturer Impact Analysis. In the Engineering Analysis, the maximum technologically feasible efficiency level is determined.

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Agenda

This presentation is organized into the following key areas:

1. Objectives and Strategic Relevance
2. **Technical Approach**
3. Resources and Schedules
4. Results

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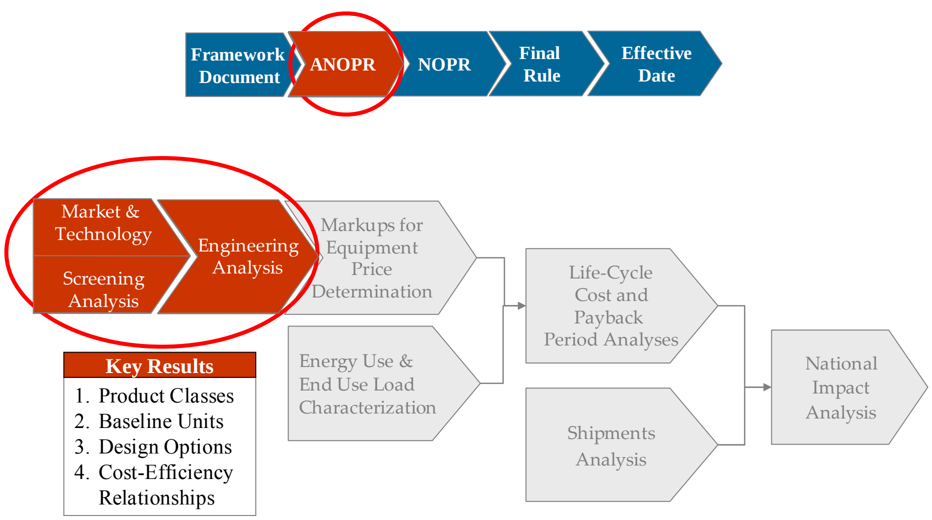
Overall Process

During the ANOPR phase of the rulemaking process, the Screening and Engineering Analyses produce four key results that feed into the rest of the analytical process.



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Market and Technology Assessment >> Overview

The analysis begins with the Market and Technology Assessment to identify technologically feasible options that manufacturers could use to attain higher energy efficiency levels.

Purpose

» To characterize the market and determine **product classes** and **baseline units**;
» To identify potential **design options** or efficiency levels for each of the product Classes to be used as input to determine what technologies manufacturers could utilize to attain higher energy efficiency levels.

Process

1. Identify trends in product characteristics
2. Identify existing and past technology options and prototype designs
3. In consultation with interested parties, develop a list of technologies than can and should be considered in the analysis.
4. Initially, the technologies will encompass all those considered to be technologically feasible and will serve to establish the maximum technologically feasible

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Market and Technology Assessment >> Product Classes

The Market and Technology Assessment designates product classes.

» Products may be separated into product classes if their capacity or other performance-related features or attributes including those that provide utility to the consumer and affect efficiency and as such warrant the application of individual energy-efficiency standards. Such different standards would then be formulated for the different product classes.

» In general, classes are defined using information obtained in discussions with manufacturers, trade associations, and other interested parties. Product classes are key issues addressed at the Framework and ANOPR workshops.

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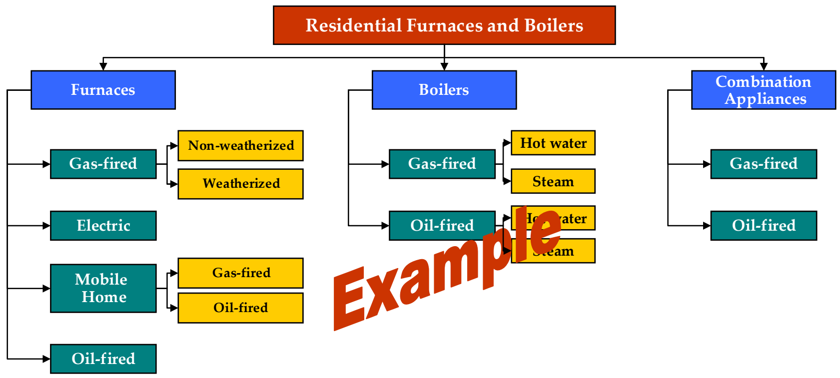
Market and Technology Assessment >> Product Classes

As an example, the following chart presents the breakdown of product classes developed for residential furnaces and boilers



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Market and Technology Assessment >> Baseline Units

After the product classes are chosen, the characteristics of the baseline unit for each class are defined.

» Defines a reference point against which changes in efficiency and cost can be measured;

» Represents a commercially available unit including operating capabilities, energy efficiency and price;

» Typically just meets required energy conservation standards;

» The baseline model is used in the Life-Cycle Cost and Payback Analyses;

» To determine energy savings and change in price, each higher efficiency design option is compared with the baseline model.

The typical definition of a baseline unit includes the key performance and technical specifications as included in this example from residential furnaces and boilers.

Product Classes		Input Capacity[1] (Btu/hr)	Efficiency[2] (AFUE)	Equipment Characteristics			
				Config-uration [3]	Heat Exchanger[3]	Ignition[3]	Draft[3]
Furnaces	**Non-Weatherized Gas-Fired Furnaces**	75,000	78	Upflow	Clam Shell or Tubular	Hot Surface	Induced
Furnaces	**Weatherized Gas-Fired Furnaces**	75,000	78	Horizontal	Clam Shell or Tubular	Hot Surface	Natural
Furnaces	**Mobile Homes Gas-Fired Furnaces**	70,000	75	Downfl[illegible]	Drum	Standing Pilot	Natural
Furnaces	**Oil-Fired Furnaces**	105,000	7[illegible]	Upflow	Drum	Intermittent Ignition	Induced
Boilers	**Gas-Fired Hot Water Boilers**	140,000	80	N/A	Sectional, Dry-base, Cast Iron	Standing Pilot	Natural
Boilers	**Oil-Fired Hot Water Boilers**	105,000	80	N/A	Sectional, Wet-base, Cast Iron	Intermittent Ignition	Induced

Example

Sources:
[1] Stakeholders' Input
[2] NAECA Minimum Standards
[3] Manufacturer Interviews, Market Assessment

The initial list of design options developed during the Technology Assessment.

- Purpose: identify design options that improve efficiency and determine which of these to evaluate and which to screen out.
- Screening Criteria:
  - Technological feasibility; Technologies incorporated in commercial products or in working prototypes will be considered technologically feasible;
  - Practicability to manufacture, install and service; If mass production of a technology in commercial products and reliable installation and servicing of the technology could be achieved on the scale necessary to serve the relevant market at the time of the effective date of the standard, then that technology will be considered practicable to manufacture, install and service
  - Adverse impacts on product utility or product availability; . If it is determined that a technology will have significant adverse impacts on health or safety, it will not be considered further.
  - Adverse impacts on health or safety; . If it is determined that a technology will have significant adverse impacts on health or safety, it will not be considered further.

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Screening Analysis >> Design Options

For example, for residential furnaces and boilers the following design options were considered.

- » Improved Heat Exchanger Effectiveness
- » Direct Vent
- » Induced or Forced Draft
- » Air-Atomized Burner with Modulation**
- » Infrared Burner
- » Fuel Filtration**
- » Delayed Action Oil Pump Solenoid Valve**
- » Condensing Secondary Heat Exchanger
- » Electronic Ignition
- » Modulating Operation
- » Increased or Improved Insulation*
- » Pulse Combustion***
- » Increased Motor Efficiency
- » Increased Blower Impeller Efficiency

*weatherized gas furnaces only **oil equipment only *** gas equipment only

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Screening Analysis >> Results

After the screening criteria is applied, options that do not meet the screening criteria are abandoned. In this example, several design options for distribution transformers were screened out.

Design Option	Screening Criteria Not Met
Silver as a conductor material	Practicability to manufacture, install and service
High Temperature Superconductors	Technological feasibility
Amorphous Core Material in Stacked Core Configuration	Technological feasibility; Practicability to manufacture, install and service
Carbon Composite Materials for Heat Removal	Technological feasibility
High Temperature Insulating Material	Technological feasibility
Solid-State (power electronics) Technology	Technological feasibility

Example

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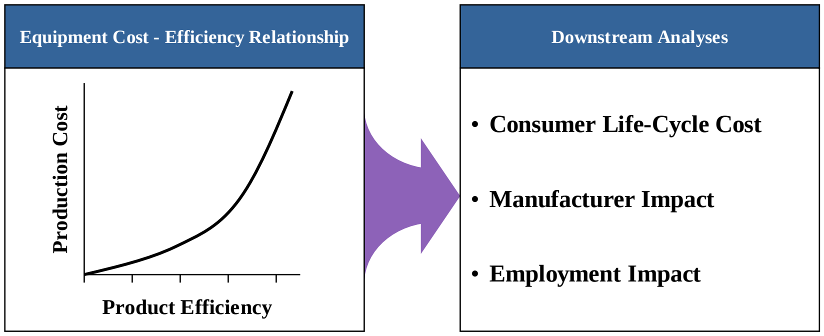
Engineering Analysis >> Overview

In the Engineering Analysis, cost-efficiency relationships are developed, estimating manufacturer's costs of achieving increased efficiency levels, and determining the maximum technologically feasible efficiency level



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Engineering Analysis >> Process

The Engineering Analysis estimates the relationship between costs and energy efficiency between baseline units and more efficient equipment by incorporating the design options that passed the Screening Analysis.

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The cost/efficiency relationships used in the analysis must possess certain characteristics.

- **Credible**
  - based on acceptable estimation techniques
  - incorporates and reconciles available data from multiple sources
- **Transparent**
  - publicly accessible
  - protects proprietary information
- **Specific**
  - sufficient detail to reduce ambiguity or misinterpretation
  - a single set of cost-efficiency estimates
  - quantified uncertainties
- **Timely**
  - available prior to scheduled deadlines

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The Engineering Analysis may use one or more of three approaches.

- The **Efficiency Level Approach** relies on costs provided by manufacturers or from retail surveys to estimate the costs for various efficiency levels. (clothes washers, residential air conditioners)
- The **Design Options Approach** uses estimates of the costs and performance of particular designs that increase efficiency. Design option efficiency increases can either be based on manufacturer or component supplier estimates or through the use of engineering computer simulation models. (water heaters)
- The **Cost Assessment Approach** estimates the manufacturing costs of efficiency levels by analyzing existing products, possibly including teardown of some units on the market (commercial unitary air conditioners)

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Engineering Analysis >> Efficiency Level Approach

The Efficiency Level Approach has advantages and disadvantages.

Advantages

- Less detailed information is needed
- Performance level assumed
- Independent of any specific design path
- Accommodates different baseline units
- Useful to identify Max Technology

Disadvantages

- Difficult to independently verify accuracy of information
- Uncertainty about the costs and means of efficiency improvements
- Does not account for cost/production volume effects for higher efficiency equipment"

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Engineering Analysis >> Design Options Approach

The Design Options Approach also its advantages and disadvantages.

Advantages

- Leads to better understanding of technological and cost aspects
- Leads to consensus in manufacturing cost estimates
- ability to incorporate designs that have been demonstrated to perform in prototypes

Disadvantages

- Requires much more detailed information from manufacturers
- Department must model efficiency improvements
- Time and effort must be expended to validate the model's results
- Design combinations may be unrepresentative of several manufacturers

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Engineering Analysis >> Cost Assessment Approach

The Cost Assessment Approach is the most demanding … and accurate.

Advantages	Disadvantages
» Provides useful information including the identification of potential technological paths manufacturers could use » Based on analysis of existing products » Tear-down analysis is a complementary methodology to whichever of the engineering approaches is followed.	» Department must develop a detailed manufacturing cost estimate » More time and effort may be required than for other approaches » Often will not consider new technologies

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Engineering Analysis >> The Hybrid Approach

Based on the Department's past experience using approaches such as the Design Option and Efficiency Level Approach, recent rulemakings have evolved into a Hybrid Approach

» Gather publicly available information

» Select representative sample of products for analysis

» Work with stakeholders to identify samples for teardown (if feasible) and to obtain design data for additional samples

» Conduct computer simulations and engineering estimates to supplement the teardown analysis

» Obtain reviews by stakeholders

» Reconcile results and characterize uncertainty

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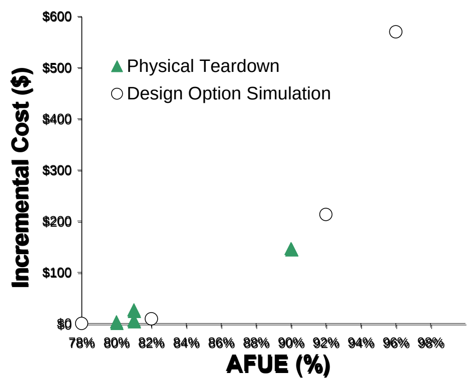
Residential furnaces and boilers is a recent example of a Hybrid Approach between Cost Assessment Approach and Design Option Simulations.

1) **Identify Baseline Units**

2) **Perform Physical Teardowns**
   - » Select Teardown Units
   - » Develop Bill of Materials
   - » Cost Model Assumptions

3) **Design Option Simulations**
   - » Identify Design Options
   - » Performance Model AFUE
   - » Cost Design Options

4) **Stakeholder Review, Finalize**



Non-weatherized Gas Furnaces

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In a tear-down, each part is measure for size, weight, specifications, method of manufacture, and manufacturing details as the unit is disassembled.

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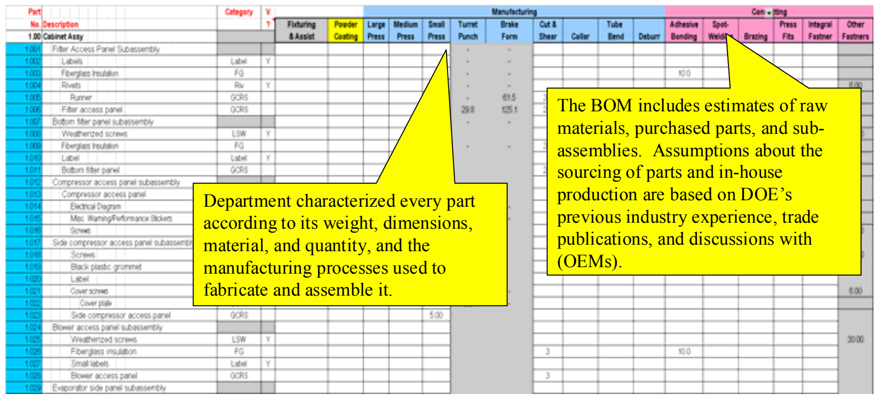
Engineering Analysis >> Cost Modeling

During the physical teardowns, the Department develops a structured Bill of Materials (BOM) cataloging every part according to its physical specifications and the manufacturing process used to produced and assemble the part.



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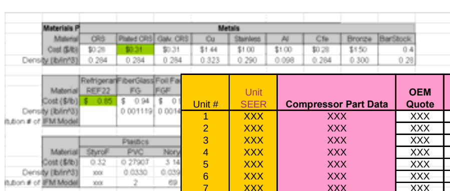
Engineering Analysis >> Cost Modeling

The BOM calculates production costs based on the price of the part or material and the labor and machinery required to fabricate or assemble it. The result is that every unit cost estimate is unique, using the initial BOM as a starting point.

Sample of a raw material data table and part list from the purchased parts sheet.



Unit #	Unit SEER	Compressor Part Data	OEM Quote	Univ. Fridge Quote	Totaline DC of NE	Model Cost	Compressor Weight Ship (lb)
1	XXX	XXX	XXX	XXX	XXX	XXX	XXX
2	XXX	XXX	XXX	XXX	XXX	XXX	XXX
3	XXX	XXX	XXX	XXX	XXX	XXX	XXX
4	XXX	XXX	XXX	XXX	XXX	XXX	XXX
5	XXX	XXX	XXX	XXX	XXX	XXX	XXX
6	XXX	XXX	XXX	XXX	XXX	XXX	XXX
7	XXX	XXX	XXX	XXX	XXX	XXX	XXX
8	XXX	XXX	XXX	XXX	XXX	XXX	XXX
9	XXX	XXX	XXX	XXX	XXX	XXX	XXX
10	XXX	XXX	XXX	XXX	XXX	XXX	XXX
11	XXX	XXX	XXX	XXX	XXX	XXX	XXX
12	XXX	XXX	XXX	XXX	XXX	XXX	XXX
13	XXX	XXX	XXX	XXX	XXX	XXX	XXX
14	XXX	XXX	XXX	XXX	XXX	XXX	XXX
15	XXX	XXX	XXX	XXX	XXX	XXX	XXX
16	XXX	XXX	XXX	XXX	XXX	XXX	XXX

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Numerical Simulations Approach

» **Design Option Modeled**
   » 'Increased Heat Exchanger Area' design option for gas-fired furnaces

» **Modeling Approach**
   » Take a unit at 78% AFUE and increase the heat exchanger size to get to 80% and 81% AFUE

» **Simulation Tool**
   » FURNACE simulation model developed by Gas Technology Institute (GTI) is used for gas-fired non-condensing furnace. The model predicts AFUE increases corresponding to the increases in heat-exchanger area. GTI developed FURNACE model to help assess in detail the impact of design options on efficiency levels.

» **Reference**
   » Jacob, F.E. et al., "SP43 Evaluation of System Options for Residential Forced-air Heating", ASHRAE Transactions 92 (2b), pp.644-73, 1992.

Another recent example of the Engineering Analysis is the process used for distribution transformers.

115 Ratings » Start with 10 product classes and 115 discrete kVA ratings

Simplify » Create Engineering Design Lines – 13 sub-groupings of the product classes

Rep Units » Select 13 representative units – one from each design line

Analysis » Select design option combinations and use Optimized Program Service (OPS) software to prepare cost-efficiency curves

Results » Provide price-efficiency relationship for use in the Life-Cycle Cost Analysis

Distribution transformers contracted an independent transformer design firm to prepare thousands of designs, spanning a wide range of efficiencies.

1) Optimized Program Service (OPS), Cleveland Ohio. Software conducted thousands of design runs based on variable input and a set of fixed material prices and design parameters

2) As an software input, net present value (NPV) of lose are varied to simulate a range of customer orders – up to a $16 A and an $8 B, creating a database of transformer designs

3) Between 2,500 and 5,000 unique designs were created for each of the thirteen representative units

4) OPS design software output includes

- » Bill of materials
- » Core construction and winding instructions, including dimensions, turns, insulation, and cooling ducts
- » Labor required for each task
- » Electrical analysis report, including efficiency

Bill of Materials and Labor for medium voltage, dry-type, 3-phase, 1500kVA

A$ Input	$1.00
B$ Input	$0.80
Efficiency at 50% load	99.14%

Material item	Type	Quantity	$ each	$ total
Core Steel* (lb)	M3-.009	6610	$ 0.81	$ 5,363.99
Primary winding* (lb)	Copper wire, rectangular 0.1 x 0.2	1044	$ 2.00	$ 2,092.85
Secondary winding* (lb)	Copper strip, thickness range 0.02-0.045	626	$ 2.27	$ 1,422.06
Winding form & insulation* (lb)	Nomex insulation	90	$ 18.11	$ 1,635.72
Enclosure	12-gauge steel	1	$ 780.41	$ 780.41
Core Clamp	-	1	$ 125.00	$ 125.00
Nameplate	-	1	$ 0.65	$ 0.65
LV Buss Bar (ft.)	-	16	$ 12.00	$ 192.00
HV Tap Board	-	3	$ 9.00	$ 27.00
HV Terminals	-	1	$ 135.00	$ 135.00
Winding Combs (lb.)	-	82	$ 10.00	$ 824.84
Duct Spacers (ft.)	-	1140	$ 0.56	$ 638.54
Impregnation (gal.)	-	28	$ 17.80	$ 497.15
Misc. Hardware	-	1	$ 54.00	$ 54.00
Scrap Factor		1.0%		$ 105.15
Additional Scrap on Core**		4.0%		$ 214.56
Total Material Cost				$14,108.91

Labor item	hours	rate	$ total
Lead dressing	1.00	42.77	$ 42.77
Inspection	0.25	42.77	$ 10.69
Preliminary Test	0.50	42.77	$ 21.39
Final Test	0.75	42.77	$ 32.08
Packing	2.00	42.77	$ 85.54
Marking and Miscellaneous	2.20	42.77	$ 94.09
Winding the Primary	17.72	42.77	$ 757.83
Winding the Secondary	2.25	42.77	$ 96.23
Core Stacking	8.99	42.77	$ 384.52
Core Assembly	6.00	42.77	$ 256.62
Enclosure Forming and Painting	8.00	42.77	$ 342.16
Handling and Slitting Factor (on material)	1.50%		$ 157.72
Total Labor	49.659	42.77	$ 2,281.64
Manufacturing Cost (Material + Labor)			$16,390.55
Factory Overhead (Materials only)	12.5%		$ 1,763.61
Non-production Cost Markup	25.0%		$ 4,538.54
Manufacturer Selling Price			$22,692.71

* indicates those items to which the scrap factor (1.0%) and the handling and slitting factor (1.5%) are applied.
** additional scrap on core due to mitering process.

This bill of materials is based on non-rounded core dimensions.

Sample Bill of Materials
1500kVA three-phase medium-voltage (95kV BIL) dry-type with M3 core steel and copper primary and secondary windings

Comparisons were made across the engineering design database to real world units to verify the integrity of the software and resultant designs.

- » Carefully reviewed design option combinations and construction techniques applied in the design phase
- » Compared designs to catalogue data – dimensional, weight, efficiency
- » Compared designs to cost and losses from public utility bids posted in the last five years (liquid-immersed)
- » Contracted independent transformer design engineer to prepare designs given same input parameters. Designs found to be the same.
- » Conducted software modeling, testing and tear-down analysis on six transformers. Software found to be highly accurate.
- » Verified the design database through interviews with manufacturers
  - » **Both manufacturers who use OPS software and those who have their own proprietary design software**

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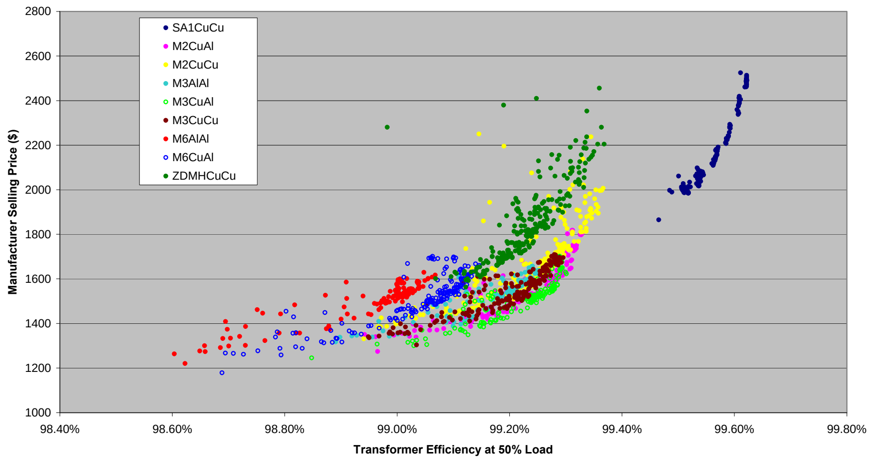
Engineering Analysis >> Typical Results

This graphs provides an example of the typical cost-efficiency relationships that result from the Engineering Analysis. In this, data is plotted for a representative liquid-immersed single-phase pad-mounted transformer with a 50 kVA rating.



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Energy Efficiency and Renewable Energy

Agenda

1. Objectives and Strategic Relevance
2. Technical Approach
3. **Resources and Schedules**
4. Results

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Energy Efficiency and Renewable Energy

Analysis Team

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DOE

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NCI

Group Management

Mike Rivest
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Product Manager

Aris Marantan CUAC	Aris Marantan Graham Stevens Res. F&B	Barclay Gibbs Distribution Transformers

Cross-Cutting Support

Barclay Gibbs	Analytical Methodology
Graham Stevens	Manufacturing Cost Estimation
Federico Garcia-Lopez	Financial Modeling

Cross-Cutting Rulemaking Oversight

Ed Levy Legal and Regulatory	Ed Barbour Cross-cutting Analysis	Mike Scholand Quality Control

Technical Consultants

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Energy Efficiency and Renewable Energy

Schedule

Distribution Transformers Schedule

» Initiation Date: November 1, 2000

» Dates of Intermediate Phase Completions or Go/No-Go Points: Advance Notice of Proposed Rulemaking (ANOPR) published July 29, 2004; ANOPR Public Meeting on September 28, 2004; ANOPR Comment Period ended November 9, 2004.

» The Regulatory Agenda calls for the Notice of Proposed Rulemaking (NOPR) to be published in September, 2006. Prior to publishing the NOPR, the Regulatory Agenda calls for a Technical Support Document (TSD) to be reviewed by the Department by September, 2005.

» The Regulatory Agenda calls for a Final Rule to be published by September, 2007.

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Schedule

Residential Furnaces and Boilers Schedule

» Initiation Date: July 17, 2001

» Dates of Intermediate Phase Completions or Go/No-Go Points: Advance Notice of Proposed Rulemaking (ANOPR) published July 29, 2004; ANOPR Public Meeting on September 29, 2004; ANOPR Comment Period ended November 10, 2004.

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Agenda

1 Objectives and Strategic Relevance

2 Technical Approach

3 Resources and Schedules

4 **Results**

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Energy Efficiency and Renewable Energy

Accomplishments and Status

» **Distribution Transformers**
  - » Framework Document – November 1, 2000
  - » ANOPR Internet Webcast – August 10, 2004
  - » ANOPR and TSD published - July 29, 2004
  - » ANOPR Public Meeting – September 28, 2004
  - » Regulatory Agenda calls for NOPR TSD to be completed - September, 2005
    - – Shipments and National Impact analyses completed as of May, 2005
  - » Regulatory Agenda calls for NOPR to be published - September, 2006
  - » Regulatory Agenda calls for Final Rule to be published - September, 2007

» **Residential Furnaces and Boilers**
  - » Framework Document - July 17, 2001
  - » ANOPR Internet Webcast – August 17, 2004
  - » ANOPR and TSD published July 29, 2004
  - » ANOPR Public Meeting – September 29, 2004
  - » Regulatory Agenda calls for TSD to be completed - September, 2005
    - – Shipments and National Impact analyses completed as of May, 2005
  - » Regulatory Agenda calls for NOPR to be published - September, 2006
  - » Regulatory Agenda calls for Final Rule to be published - September, 2007

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Energy Efficiency and Renewable Energy

Technical Documents

For both rules, major accomplishments are the publication of the Technical Support Document and the Analytical Spreadsheets that accompanied the ANOPR.

Distribution Transformers

» U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy, Technical Support Document: Energy Efficiency Program for Commercial and Industrial Equipment: Electrical Distribution Transformers, July, 2004. Washington, DC.

<http://www.eere.energy.gov/buildings/appliance_standards/commercial/dist_trans_tsd_061404.html>

» U.S. Department of Energy-Office of Energy Efficiency and Renewable Energy, ANOPR Analytical Spreadsheets, ANOPR engineering analysis results spreadsheets for all 13 design lines, April 2004. Washington, DC.

<http://www.eere.energy.gov/buildings/appliance_standards/commercial/distribution_transformers_spreadsheets.html>

Residential Furnaces and Boilers

» U.S. Department of Energy-Office of Energy Efficiency and Renewable Energy, Technical Support Document: Energy Efficiency Program for Consumer Products: Energy Conservation Standards for Residential Furnaces and Boilers, September, 2004. Washington, DC.

<http://www.eere.energy.gov/buildings/appliance_standards/residential/furnaces_boilers_1113_r.html>

» U.S. Department of Energy-Office of Energy Efficiency and Renewable Energy, Residential Furnaces and Boilers ANOPR Analytical Tools, September, 2004. Washington, DC.

<http://www.eere.energy.gov/buildings/appliance_standards/residential/furnace_boiler_draft_analysis.html>

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Appliance Standards Peer Review

Markups for Appliance Price Determination, Life-Cycle Cost and Payback Period Analysis, Life-Cycle Cost Consumer Sub-group Analysis

James McMahon

Lawrence Berkeley National Laboratory

June 28, 2005

U.S. Department of Energy
Energy Efficiency and Renewable Energy

OUTLINE:
Life Cycle-Cost and Payback Period Analysis, including Markup Analysis

- **REQUIREMENTS and OBJECTIVES**
- **TECHNICAL APPROACH**
  - Markup Analysis transformers Manufacturer Price (from Engineering Analysis) to Consumer Price
  - Life-Cycle Cost and Payback Period Analysis examines tradeoff between first cost and operating cost
- **PROJECT TEAM**
- **ACCOMPLISHMENTS and STATUS**

2

Requirements

- **The Energy Policy Conservation Act (EPCA) directs DOE to consider a number of factors when specifying a new energy efficiency standard, including:**
  - "the savings in operating costs throughout the average life of the covered product in the type (or class) compared to any increase in the price of, or in the initial charges for, or maintenance expenses of, the covered products which are likely to result from the imposition of standards."

- **Life-cycle cost and payback period are measures of the tradeoff between price and operating cost**
  - Consumer Life-Cycle Cost (LCC) and Payback Period (PBP) Analysis calculates net changes in consumer costs from potential efficiency standards
  - Consumer LCC Sub-group Analysis identifies significant consumer sub-groups that may be significantly affected by a uniform national standard

3

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Energy Efficiency and Renewable Energy
Life-Cycle Cost and Payback Period Analysis

Objectives

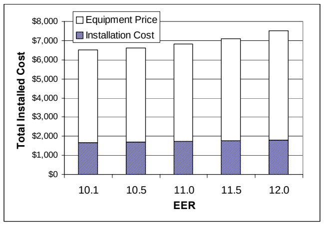
- **LCC and Payback Period Analysis, LCC Consumer Sub-group Analysis, and Markup Analysis estimate expected effects of energy efficiency standards on consumers**
  - Ensures that the Building Technologies Program fulfills legislated requirements and fulfills goals of improving building and equipment energy efficiency
  - Satisfies the legislative mandate for DOE to analyze possible energy efficiency standards for appliance, lighting and equipment

4

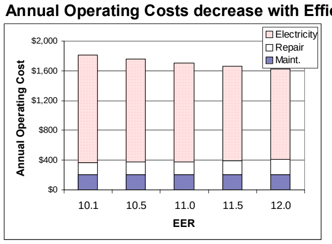
Life-Cycle Cost depends on Total Installed Cost (First Cost) and Annual Operating Costs

Example: Commercial Unitary Air Conditioners, >65,000 Btu/h to <135,000 Btu/h

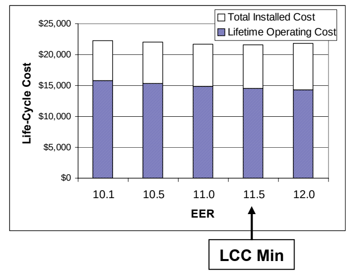
Total Installed Cost increases with Efficiency



Annual Operating Costs decrease with Efficiency



Life-Cycle Cost minimum based on trade-off of higher installed costs and lower operating costs



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Technical Approach

- **Markups for Appliance Price Determination**
  - Characterize channels for distributing equipment from manufacturers to consumers
  - Estimate prices customers are likely to pay for current and higher efficiency products, based on expected manufacturer prices from engineering analysis
- **Life-Cycle Cost and Payback Period Analysis**
  - Quantify the consumer net impacts for products at different energy efficiency levels under field conditions
  - Account for variability among key variables, including equipment price, equipment lifetime, operating behavior, energy prices
- **Life-Cycle Cost Consumer Sub-group Analysis**
  - Assess whether significant sub-groups of consumers will bear significant adverse impacts

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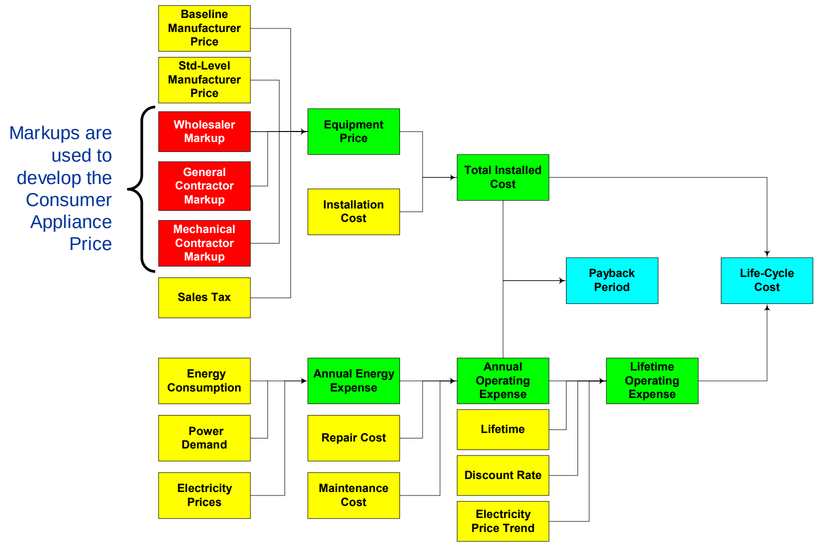
Technical Approach

Calculating Life-Cycle Costs and Payback Periods



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Markups from Manufacturer to Consumer Price

Markups are applied to Manufacturer Ex-Factory Prices to obtain Consumer Prices

- **METHOD**
  - Characterize distribution channels and market segments
  - Analyze firm direct costs, expenses, and profits for wholesalers, contractors and builders
- **INPUT**
  - Firm balance sheets, trade association reports or U.S. Census Bureau data
- **RESULTS**
  - Baseline markup
  - Incremental markup

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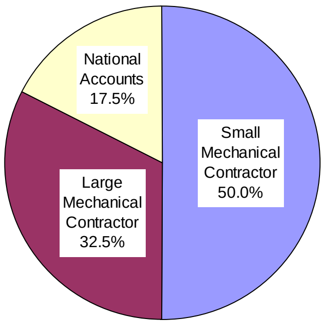
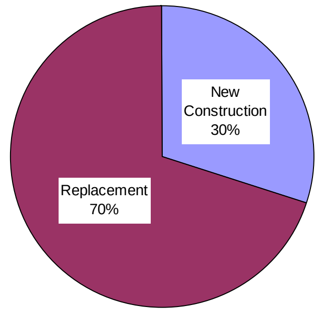
Markups depend on Distribution Channels and Market Segments

- **EXAMPLE: Commercial heating and cooling equipment**



Distribution channel depends on size of mechanical contractor and whether the customer purchases directly from the manufacturer (i.e., national account)



Two construction types: replacement & new construction

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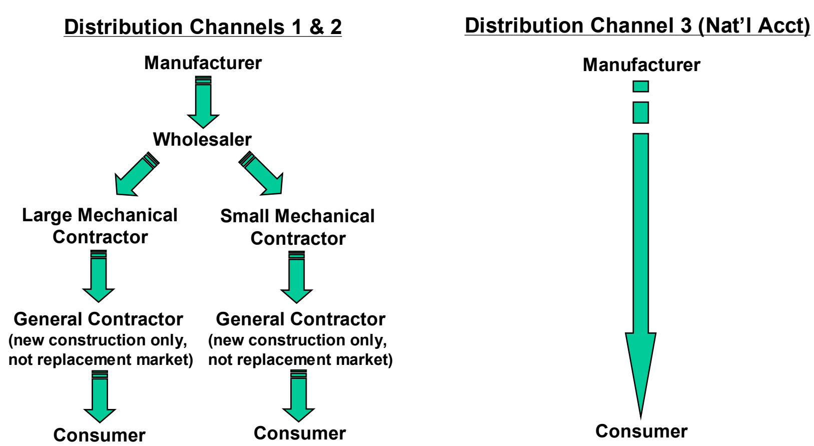
Distribution Channels consist of Several Parties

- **EXAMPLE: commercial heating and cooling equipment**



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Two types of Markups: Baseline and Incremental

- **Markups relate customer price to cost of goods sold (CGS)**
- **Baseline markups relate price to cost prior to a change in efficiency**
  - Baseline markups indicate a customer price that covers all of a Wholesaler's or Contractor's expenses plus profit
  - Direct labor costs are included
- **But some costs remain constant when CGS increases**
- **Incremental markups relate the incremental change in customer price to the incremental change in CGS**
  - Incremental markups cover only expenses that vary with CGS – in this case, expenses that increase due to an increase in equipment efficiency
  - For example, direct labor costs do not vary with efficiency induced changes in CGS

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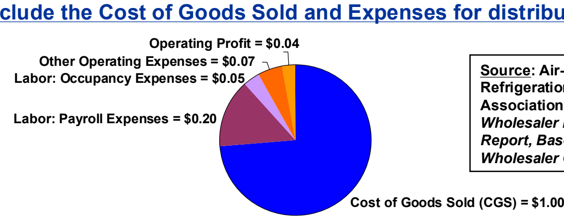
Markups from Manufacturer to Consumer Price

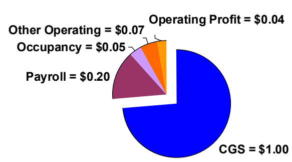
Wholesaler Markup Example

Revenues include the Cost of Goods Sold and Expenses for distributing equipment



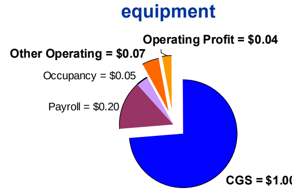
Source: Air-conditioning & Refrigeration Wholesalers Association (ARW), *1998 Wholesaler PROFIT Survey Report, Based on 1997 Wholesaler Operations*, 1998.

The baseline markup covers expenses incurred in distributing baseline equipment



Baseline Markup = 1.36

The incremental markup covers additional expenses incurred in distributing efficient equipment



Incremental Markup = 1.11

Note that Operating Profits will scale up with Cost of Goods Sold

Contractor Markup Example

Mechanical Contractor

Cost of Goods Sold	$1.00
Labor Expenses:	
Salaries, Payroll	**$0.23**
Rental, Occupancy	**$0.02**
Other Expenses:	
Advertising, Insurance, etc.	**$0.21**
Operating Profit	**$0.07**

BASELINE →

For baseline conditions

Cost of Goods Sold	$1.00
Labor Expenses	*$0.25*
Other Expenses	*$0.28*
Baseline Markup =	1.53

INCREMENTAL →

For an incremental change in CGS

Cost of Goods Sold	$1.00
Labor Expenses	$0.25
Other Expenses	*$0.28*
Incremental Markup =	1.28

General Contractor

Cost of Goods Sold	$1.00
Labor Expenses:	
Salaries, Payroll	**$0.09**
Rental, Occupancy	**$0.01**
Other Expenses:	
Advertising, Insurance, etc.	**$0.01**
Operating Profit	**$0.12**

BASELINE →

For baseline conditions

Cost of Goods Sold	$1.00
Labor Expenses	*$0.11*
Other Expenses	*$0.13*
Baseline Markup =	1.24

INCREMENTAL →

For an incremental change in CGS

Cost of Goods Sold	$1.00
Labor Expenses	$0.11
Other Expenses	*$0.13*
Incremental Markup =	1.13

National Accounts

- **National accounts are large customers that are able to negotiate prices directly with the manufacturer**
- **"National Account" markup is expected to be lower than other markups because of fewer "middle men," but how much less is uncertain.**
- **The "National Account" markup is taken to be ½ of the product of the wholesaler, mechanical contractor, and general contractor markups.**

Converting Baseline and Standard Level Manufacturer Prices to Customer Prices

		Small Mech. Contractor Market Share=50%		Large Mech. Contractor Market Share=32.5%		National Accounts Market Share=17.5%		Weighted-Average New & Replacement		Weighted-Average All	
		Baseline	Incremental	Baseline	Incremental	Baseline	Incremental	Baseline	Incremental	Baseline	Incremental
New Construction Market Share=30%	Wholesaler	1.36	1.11	1.36	1.11	1.69	1.27	2.43	1.60	2.31	1.56
	Mechanical Contractor	1.48	1.26	1.35	1.18						
	General Contractor	1.24	1.13	1.24	1.13						
	Sales Taxes	1.07	1.07	1.07	1.07	1.07	1.07				
	Overall	2.66	1.68	2.42	1.59	1.80	1.35				
Replacement Market Share=70%	Wholesaler	1.36	1.11	1.36	1.11	1.60	1.24	2.27	1.54		
	Mechanical Contractor	1.70	1.37	1.55	1.29						
	General Contractor	NA	NA	NA	NA						
	Sales Taxes	1.07	1.07	1.07	1.07	1.07	1.07				
	Overall	2.47	1.63	2.24	1.53	1.71	1.32				

Example Calculation

	Manufacturing Price		Customer Price		Deduced
	Incremental	Total	Incremental	Total	Markups
Baseline	-	$2,000	-	$4,630	2.31
Standard Level 1	$300	$2,300	$468	$5,098	2.22

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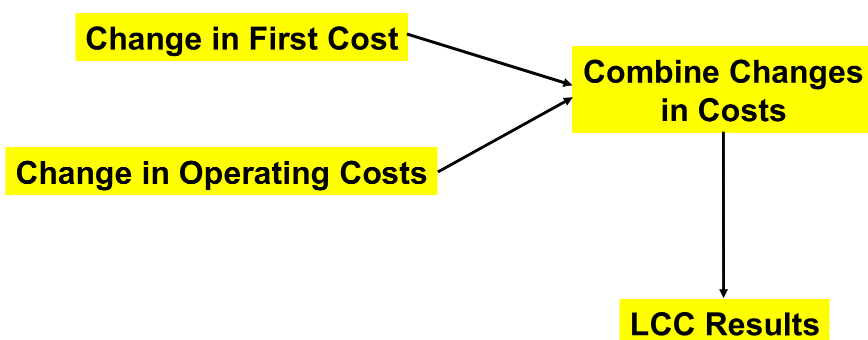
Basic LCC Process Diagram

- Economic evaluation from the consumer perspective



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Basic LCC Process

- **LCC equals first cost plus sum of annual operating costs discounted to base year**
  - First cost includes installation
  - Maintenance and repair costs are included, as appropriate
- **Implement in MS Excel® spreadsheet**
  - Monte Carlo simulations sample from input distributions
- **Test sensitivities to key inputs**
- **Express results as LCC difference**
  - Baseline LCC minus candidate standard LCC = net LCC savings (+) or net LCC costs (-)

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Key Inputs

- **Incremental equipment prices**
  - Apply markups to manufacturer incremental prices from Engineering Analysis
- **Energy prices**
- **Operating behavior**
- **Equipment lifetimes**
- **Discount rates**
- **Other inputs**

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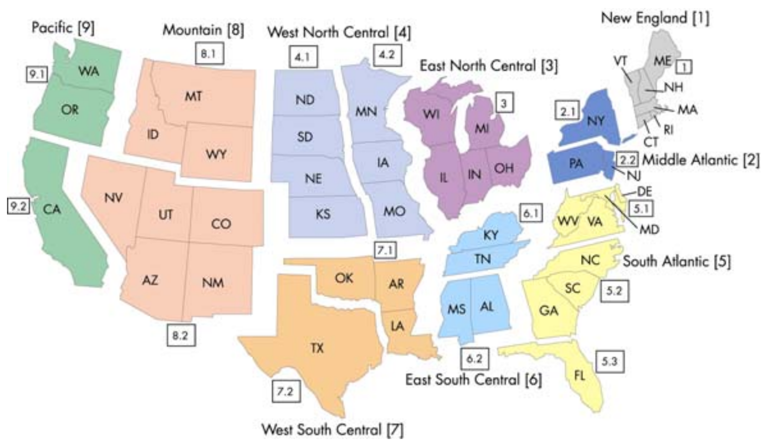
Energy Prices are a Key Input

- **Range of current energy prices is based on either actual bill data or utility tariffs, accounting for variability among applications**
  - Energy prices for residential households are obtained from monthly billing data (monthly consumption and expenditure) from the Energy Information Administration's (EIA) Residential Energy Consumption Survey (RECS)
  - Energy prices for commercial equipment are calculated from sample of utility tariffs
- **Future energy prices are based on energy price trends**
  - DOE/EIA Annual Energy Outlook reference case
  - High and low scenarios
- **Marginal energy prices reflect expected change in bill, not average prices**

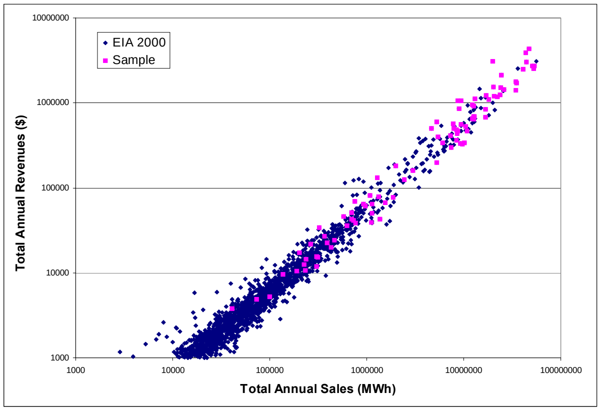
Commercial Consumer Electricity Prices Based on Tariffs by Subdivision

- **17 subdivisions from combinations of Census Divisions (9), Climate Regions (9), Electricity Transmission Grid (FL, PJM, NY, TX)**



Commercial Tariffs taken from a sample of Utilities

- **Selected sample of utilities to obtain high coverage of U.S. sales and customers, while representing all regions and utility types**



CUSTOMER COVERAGE BY SUBDIVISION					
			Customers		
No.	Subdivision	States	Total	Private	Public
1	New England	CT,MA,ME,NH,RI,VT	39%	43%	4%
2.1	New York	NY	75%	73%	88%
2.2	Mid Atlantic	NJ,PA	47%	48%	8%
3	EN Central	IL,IN,MI,OH,WI	39%	44%	8%
4.1	W-WN Central	KS,ND,NE,SD	12%	27%	5%
4.2	E-WN Central	IA,MO,MN	46%	59%	10%
5.1	N-S Atlantic	DE,MD,VA,WV	67%	73%	13%
5.2	Mid-S Atlantic	GA,NC,SC	64%	89%	12%
5.3	Florida	FL	58%	72%	15%
6.1	N-ES Central	KY,TN	21%	47%	11%
6.2	S-ES Central	AL,MS	43%	69%	10%
7.1	N-WS Central	AR,LA,OK	44%	60%	3%
7.2	Texas	TX	22%	24%	19%
8.1	N-Mountain	ID,MT,WY	40%	53%	10%
8.2	S-Mountain	AZ,CO,NM,NV,UT	46%	72%	6%
9.1	N-Pacific	OR,WA	38%	48%	17%
9.2	California	CA	66%	81%	20%
9.3	Alaska	AK	21%	0%	23%
9.4	Hawaii	HI	63%	63%	NA
	USA		48%	59%	14%

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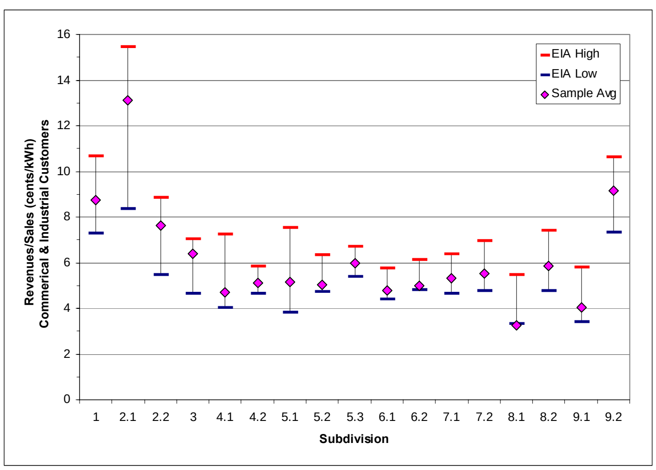
Sample of Utilities is representative based on EIA data

- **Sample utilities have average *Revenue/Sales* values within range of EIA listed utilities**



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Marginal Energy Prices

Utilities generally have several tariffs

- **Example: Commercial/Industrial Tariffs from Boston Edison Company, Boston MA**

Tariff	Tariff Limits (kW) Min	Max
General Service G-1 w/o Demand Meters	0	10
General Service G-2 w/ Demand	10	150
Time of Use Rate T-2	150	99999999

- **Each tariff is a combination of fixed, energy, and demand charges (General Service Tariff G-2 w/ Demand)**

Charge Description	Summer Rates	Winter Rates
Fixed Charges ($)	18.19	18.19
Energy Charges		
first 200 kWh ($/kWh)	0.1117	0.0449
next 150 hours of billing demand ($/kWh)	0.0245	0.0116
for all additional kWh ($/kWh)	0.0050	0.0045
Demand Charges		
in excess of 10kW ($/kW)	23.51	10.97

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Marginal Energy Prices

Calculate annual electricity bill from the tariff and each building's energy & demand characteristics

- **Example: Boston Edison Company, Boston MA**
  General Service Tariff G-2 w/ Demand
  Season – Summer; Month – July
  C&I Revenue/Sales = 9.63 ¢/kWh

CBECS Bldg ID	Bldg Type	Area *sq. ft.*	Consumption *kWh*	Demand *kW*	Marginal Rate *cents/kWh*
7273	Small Office	3000	3329	10.27	5.75
6274	Small Office	5001	5468	17.77	12.13
41	Restaurant	900	22024	50.90	8.43
5650	Small Office	23750	27455	86.08	11.42
4054	Warehouse	55000	33703	125.48	13.92

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Marginal electricity rates for commercial air-conditioning consumers are a function of building load factor

- **Building load factor indicates the relative significance of peak demand use**
  - The higher the load factor the lower peak demand is to overall energy consumption
  - Bldg load factor = Annual energy use (kWh) / [Peak demand (kW) • 8760 hours]

MARGINAL ELECTRICITY RATES BY SUBDIVISION (cents/kWh)					
			Building Load Factor		
No.	Subdivision	States	< 30%	30% to 50%	> 50%
1	New England	CT,MA,ME,NH,RI,VT	9.1	7.6	6.7
2.1	New York	NY	13.1	13.4	10.4
2.2	Mid Atlantic	NJ,PA	11.8	10.7	8.5
3	EN Central	IL,IN,MI,OH,WI	11.1	9.4	8.0
4.1	W-WN Central	KS,ND,NE,SD	6.1	5.9	5.3
4.2	E-WN Central	IA,MO,MN	6.1	6.0	5.4
5.1	N-S Atlantic	DE,MD,VA,WV	9.1	7.4	6.3
5.2	Mid-S Atlantic	GA,NC,SC	7.5	7.4	5.2
5.3	Florida	FL	7.7	7.8	7.3
6.1	N-ES Central	KY,TN	6.7	6.2	5.8
6.2	S-ES Central	AL,MS	6.7	6.3	5.2
7.1	N-WS Central	AR,LA,OK	6.1	5.9	5.4
7.2	Texas	TX	10.2	9.3	7.0
8.1	N-Mountain	ID,MT,WY	NA	6.1	5.8
8.2	S-Mountain	AZ,CO,NM,NV,UT	9.1	8.1	7.5
9.1	N-Pacific	OR,WA	NA	4.4	3.1
9.2	California	CA	19.6	18.4	18.2
	USA		11.3	10.1	7.3

92% of building sample has a load factor less than 50%.

As a result, most of building sample has relatively high marginal electricity rates.

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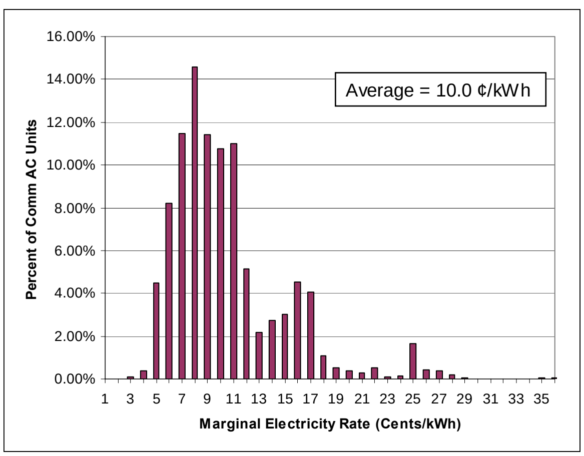
Marginal Energy Prices

Marginal electricity rates vary over a wide range of values



EXAMPLE: Commercial unitary air conditioners, 2001

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Discount Rates are used to calculate the present value of future operating costs

- **Discount rates are derived from estimates of the cost of capital for companies that purchase the product (e.g., commercial air conditioners)**
- **Discount rates are used to reduce the future value of cash flows to be derived from a typical company project or investment**
- **Cost of capital is calculated from the weighted-average cost to the firm to obtain equity and debt financing**

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Cost of Equity and Debt Financing

- **Cost of equity financing (k_e) is estimated using the capital asset pricing model (CAPM)**

$$k_e = R_f + (\beta \cdot ERP)$$

Where,
R_f = expected return of risk free asset;
β = beta of the company stock; and
ERP = the expected equity risk premium or the amount by which investors expect the future return on equities to exceed that on the riskless asset

- **Cost of debt financing (k_d) is the yield or interest rate paid on money borrowed by a company**
  - Cost of debt includes compensation for default risk and excludes deductions for taxes

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Weighted-Average Cost of Capital (WACC)

- **WACC is the weighted-average cost of debt and equity financing, less expected inflation**

$$k = k_e \cdot w_e + k_d \cdot w_d$$

Where,
k = nominal cost of capital; and
w_e and w_d = proportion of equity and debt financing

- **Typical Values**
  - R_f (risk free asset return)= 5.5% (return on long-term gov't bonds)
  - *ERP* (equity risk premium) = 5.5% (ranges from 3.3% to 7.8%)
  - k_d (cost of debt after tax) = 5.9%
  - β (systematic firm risk) = 0.93
  - w_d (percent debt financing) = 44%
  - r (expected inflation) = 2.3% (average of change in GDP prices)
  - WACC = 6.1%

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Discount rates for LCC Analysis based on WACC for various ownership categories

- **WACC Sample of companies drawn for each ownership category from Value Line investment survey and listed on the Damodaran Online site**
- **Ownership category shares based on Commercial Building Energy Consumption Survey (CBECS) 1999 cooled floor space area**

Ownership Category	SIC Code	Ownership Shares	Mean Real Discount Rate (WACC)	Standard Deviation	Number Observations
Retail stores	53, 54, 56	16%	7.1%	2.1%	218
Property owners	6720	21%	5.2%	0.7%	11
Medical services	8000	7%	7.0%	1.7%	115
Industrial	1000-4000	5%	6.9%	3.2%	253
Hotels	7000	4%	5.6%	1.5%	51
Food Service	5812, 5400	5%	6.1%	1.4%	88
Office Service	5910-9913	19%	6.9%	2.1%	128
Public non-profit	N.A.	11%	3.0%	0.7%	41
Public for profit	7950, 8299	11%	7.3%	1.8%	68
Weighted Average		N.A.	**6.1%**	1.59%	N.A.

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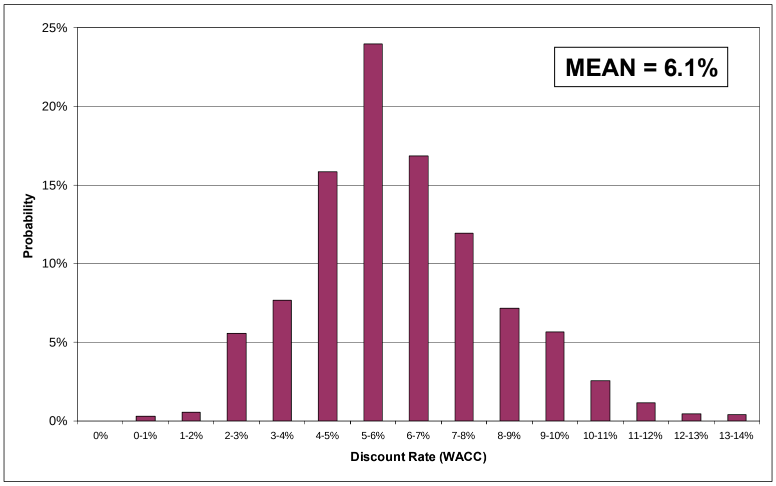
Distribution of real discount rates (WACC) for commercial air conditioner customers, 2001



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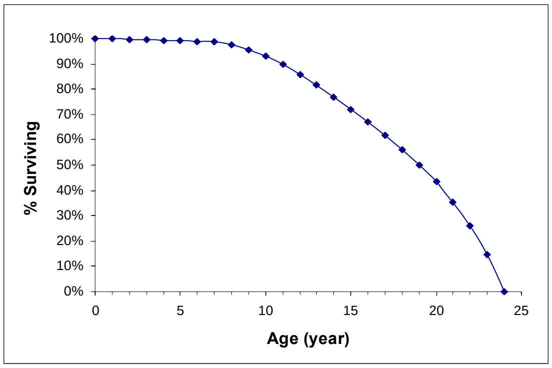
Appliance Lifetime

- **Typically characterized with survival functions**
  - Provides a better representation of actual appliance failures

Example: Residential Central Air Conditioners



- **Based on a survey of over 2100 heat pumps in the late 1980's**
- **Mean lifetime = 18.4 years**
- **Compressor replacement in 14th year**

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Other Inputs

- **Installation Costs**
  - Cost to the consumer of installing the appliance
- **Energy Price Forecasts**
  - Component of future operating costs
- **Repair Costs**
  - Cost of repairing or replacing components that have failed
- **Maintenance Costs**
  - Cost associated with maintaining the operation of the appliance

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Inputs and results account for variation among consumers

- **A consumer sample is developed where every consumer is unique**
  - Consumer sample is based on those consumers who utilize the appliance
    - Residential: RECS household records
    - Commercial: CBECS building records
- **Variability among consumers is represented using input variables defined with probability distributions**
  - For example, energy prices, discount rates, equipment lifetimes
- **Monte Carlo simulations are used to conduct the analysis**
  - Statistical technique samples from distributions for each input variable
- **Results produced as 10,000 iterations**
  - Performed with Crystal Ball®, an add-in to MS Excel®

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Life-Cycle Cost and Payback Period Analysis

Summary Sheet from LCC Spreadsheet for Commercial Unitary A/C

COMMERCIAL UNITARY AIR CONDITIONERS

LIFE CYCLE COST CALCULATION: TARIFF-BASED ELECTRICITY

USER OPTIONS:

- Sample Calculation
- Crystal Ball Simulation

Energy Price Projection	AEO 2003 - Reference Case
Start Year	2008
Product Class	7.5 tons

Installation Cost: Flat / Increasing

Repair Cost: Flat / Increasing

ASSUMPTIONS:

Lifetime *(years)*	15.4	
Discount Rate	7.1%	

BUILDING INFORMATION:

Building ID	11	
Utility ID	733	
State	DE	
Sub-Division	5.1	
Census Region	3	
Average Electricity Price	5.2	*cents/kWh*
Marginal Electricity Price	5.8	*cents/kWh*
Maximum Annual Demand	163.5	*kW*
Square Footage	25,000	*sq.ft.*
% Cooling Package	100.0	%
Installation Cost Multiplier	1.08	
Number of A/C Units	10.48	
Building Type	SmRet	
Owner-occupied	Yes	

LIFE CYCLE COSTS RESULTS:

Year of Purchase	2008
Year Equipment Retires	2022
Baseline Efficiency Level	2

			Total Installed Price ($)	Annual Repair & Maint. Cost ($/yr)	Annual Elec. Bill 2008 ($/yr)	Cumul. Cash Flow ($)	Life Cycle Cost ($)	LCC Savings ($)	Payback (year)
	0	EER=9.5	$7,251	$381	$612	$20,989	$15,510		
	1	EER=10.0	$7,290	$381	$581	$20,622	$15,306	$0	0.0
Baseline >>	2	EER=10.1	$7,298	$381	$575	$20,552	$15,267	$0	0.0
	3	EER=10.5	$7,408	$385	$553	$20,434	$15,241	$27	6.1
	4	EER=11.0	$7,603	$393	$528	$20,419	$15,310	-$43	8.7
	5	EER=11.5	$7,898	$407	$504	$20,608	$15,543	-$275	13.3
	6	EER=11.8	$8,149	$418	$492	$20,869	$15,801	-$533	18.5
	7	EER=12.0	$8,359	$428	$483	$21,121	$16,036	-$769	23.9

** All costs in 2001 dollars*

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Life-Cycle Cost and Payback Period Analysis

User Options: Calculations

COMMERCIAL UNITARY AIR CONDITIONERS

LIFE CYCLE COST CALCULATION: TARIFF-BASED ELECTRICITY

USER OPTIONS:

- Sample Calculation
- Crystal Ball Simulation

Energy Price Projection	AEO 2003 - Reference Case
Start Year	2008
Product Class	7.5 tons

Installation Cost: Flat / Increasing

Repair Cost: Flat / Increasing

ASSUMPTIONS:

Lifetime *(years)*	15.4	
Discount Rate	7.1%	

BUILDING INFORMATION:

Building ID	11	
Utility ID	733	
State	DE	
Sub-Division	5.1	
Census Region	3	
Average Electricity Price	5.2	*cents/kWh*
Marginal Electricity Price	5.8	*cents/kWh*
Maximum Annual Demand	163.5	*kW*
Square Footage	25,000	*sq.ft.*
% Cooling Package	100.0	%
Installation Cost Multiplier	1.08	
Number of A/C Units	10.48	
Building Type	SmRet	
Owner-occupied	Yes	

LIFE CYCLE COSTS RESULTS:

Year of Purchase	2008
Year Equipment Retires	2022
Baseline Efficiency Level	2

Sample Calculation

Crystal Ball Simulation

** All costs in 2001 dollars*

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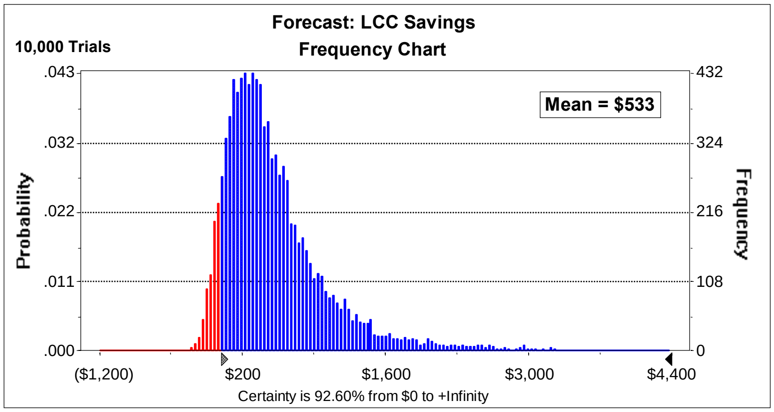
RESULTS: LCC Savings for Commercial Unitary Air Conditioners

7.5 ton (≥65,000 Btu/h and <135,000 Btu/h)

11.0 EER standard compared to 10.1 EER baseline



Mean Baseline LCC = $20,514

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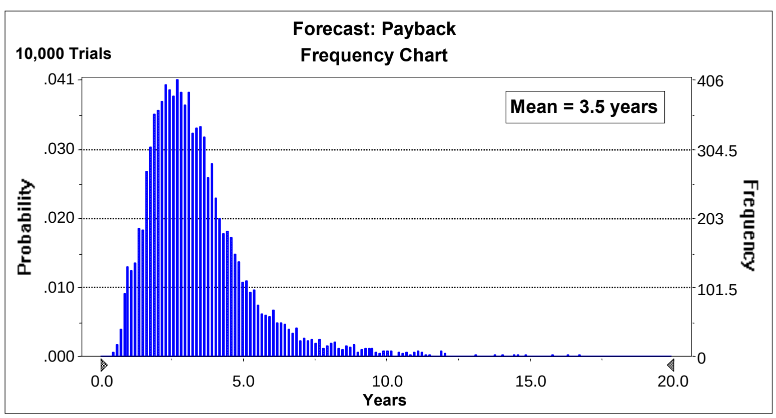
RESULTS: Payback Periods for Commercial Unitary Air Conditioners

7.5 ton (≥65,000 Btu/h and <135,000 Btu/h)

11.0 EER standard compared to 10.1 EER baseline



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Energy Efficiency and Renewable Energy

Life-Cycle Cost Sub-group Analysis

LCC Sub-group Analysis assesses whether significant sub-groups of consumers will bear significant adverse impacts

- **METHOD**
  - Same as the LCC Analysis but a smaller sample of consumers are analyzed
- **INPUTS**
  - Residential consumer sub-groups that may bear adverse impacts
    - Low-income
    - Seniors
  - Commercial consumer sub-groups that may bear adverse impacts
    - Small businesses (i.e., low annual revenues)

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U.S. Department of Energy
Energy Efficiency and Renewable Energy

Analysis Team

Ron Lewis

DOE	Jim Raba	Mohammed Khan	Antonio Bouza	Bryan Berringer	
LBNL Group Management			James E. McMahon Group Leader		
Product Managers and Engineers	Gregory Rosenquist Assistant Group Leader (Air-Conditioning and Refrigeration & HID Lamps)	Alex Lekov / James Lutz (Space-Heating and Water-Heating)	John Stoops (Distribution Transformers and Misc. Electrical)	Steve Meyers (Motors)	Peter Biermayer (Consumer Electronics, Clothes/Dish-Washers)
Engineering Support	Barbara Atkinson Andrea Denver	Victor Franco Gabrielle Woing-Parodi	Consultant Stanley Merritt		
Economists and Economic Analysts	Larry Dale Katie Coughlin Richard White Diane Fisher	Michael McNeil Camilla Whitehead Xiaomin Liu	Stuart Chaitkin Maithili Iyer Robert Van Buskirk	Utility/Environmental (NEMS) Chris Marnay Kristina LaCommare Etan Gumerman	
Rulemaking Support	LBNL Washington Laura Van Wie McGrory	Steve Meyers	Diana Morris	Karen Olson	
Computer Support	Terry Chan	Peter Chan	Chris Bolduc	Girish Ghatikar	

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Staff Resources

- **Distribution Transformers (2 Full-time Equivalent persons)**
  - FY 2001-2004 funding and staff levels reflect effort to complete ANOPR

	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	Total
Key Personnel (person-months)						
Jim McMahon, PI	1.1	1.1	1.1	1.1	0.5	4.7
John Stoops, Project Manager	6.3	6.3	6.3	6.3	3.0	28.2
Robert Van Buskirk, Analyst	4.6	4.6	4.6	4.6	4.6	23.1
Stuart Chaitkin, Analyst	4.2	4.2	4.2	4.2	2.0	18.8
Larry Dale, Analyst	0.4	0.4	0.4	0.4	0.4	1.8
Peter Chan, Analyst	1.8	1.8	1.8	1.8	1.1	8.3
Laura Van Wie McGrory, Analyst	0.0	0.0	0.0	1.8	0.9	2.7
Chris Bolduc, Analyst	1.8	1.8	1.8	1.8	1.2	7.9
Karen Olson, Analyst	0.8	0.8	0.8	0.8	0.4	3.8
Terry Chan, Analyst	1.3	1.3	1.3	1.3	0.6	5.6
Diana Morris, Admin. Support	1.9	1.9	1.9	1.9	0.9	8.6
Total (person-months)	**24.0**	**24.0**	**24.0**	**25.9**	**15.6**	**113.6**
Consultants (person-months)	0.5	0.5	0.5	0.5	0.5	2.5

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Staff Resources

- **Residential Furnaces and Boilers (2 Full-time Equivalent persons)**
  - FY 2001-2004 funding and staff levels reflect effort to complete ANOPR

	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	Total
Key Personnel (person-months)						
Jim McMahon, PI	1.0	1.0	1.0	1.0	0.5	4.4
Alex Lekov, Project Manager	5.7	5.7	5.7	5.7	2.9	25.7
Jim Lutz, Analyst	3.5	3.5	3.5	3.5	3.2	17.3
Michael McNeil, Analyst	0.4	0.4	0.4	0.4	0.4	1.8
Peter Chan, Analyst	1.2	1.2	1.2	1.2	1.1	5.8
Larry Dale, Analyst	0.4	0.4	0.4	0.4	0.4	1.8
Victor Franco, Analyst	6.3	6.3	6.3	6.3	6.3	31.5
Gabrielle Wong-Parodi, Analyst	4.8	4.8	4.8	4.8	4.8	23.8
Laura Van Wie McGrory, Analyst	0.0	0.0	0.0	1.7	0.9	2.6
Camilla Whitehead, Analyst	1.6	1.6	1.6	1.6	1.5	8.0
Steve Meyers, Analyst	1.0	1.0	1.0	1.0	0.5	4.7
Terry Chan, Analyst	1.2	1.2	1.2	1.2	0.6	5.3
Diana Morris, Admin. Support	1.8	1.8	1.8	1.8	0.9	8.2
Total (person-months)	**28.8**	**28.8**	**28.8**	**30.5**	**24.0**	**140.8**
Consultants (person-months)	1.0	1.0	1.0	0.5	0.5	4.0

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Energy Efficiency and Renewable Energy

Accomplishments and Status

- **Distribution Transformers**
  - Framework Document – November 1, 2000
  - ANOPR Internet Webcast – August 10, 2004
  - ANOPR and TSD published July 29, 2004
  - ANOPR Public Meeting – September 28, 2004
  - Regulatory Agenda calls for NOPR TSD to be completed September, 2005
    - Markup, LCC and PBP analysis, LCC Sub-group analysis completed as of May, 2005
  - Regulatory Agenda calls for NOPR to be published September, 2006
  - Regulatory Agenda calls for Final Rule to be published - September, 2007

- **Residential Furnaces and Boilers**
  - Framework Document - July 17, 2001
  - ANOPR Internet Webcast – August 17, 2004
  - ANOPR and TSD published July 29, 2004
  - ANOPR Public Meeting – September 29, 2004
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U.S. Department of Energy
Energy Efficiency and Renewable Energy

DOE Primary Technical Products

- **Distribution Transformers**
  - U.S. Department of Energy-Office of Energy Efficiency and Renewable Energy, *Technical Support Document: Energy Efficiency Program for Commercial and Industrial Equipment: Electrical Distribution Transformers*, July, 2004. Washington, DC.
  - U.S. Department of Energy-Office of Energy Efficiency and Renewable Energy, ANOPR Analytical Spreadsheets, Life-Cycle Cost Calculations by Design Line, October, 2004. Washington, DC.

- **Residential Furnaces and Boilers**
  - U.S. Department of Energy-Office of Energy Efficiency and Renewable Energy, *Technical Support Document: Energy Efficiency Program for Consumer Products: Energy Conservation Standards for Residential Furnaces and Boilers*, September, 2004. Washington, DC.
  - U.S. Department of Energy-Office of Energy Efficiency and Renewable Energy, Residential Furnaces and Boilers ANOPR Analytical Tools, October, 2004. Washington, DC.

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- **Associated Publications**
  - Wong-Parodi, Gabrielle, Lekov, Alex, Dale, Larry. Natural Gas Prices Forecast Comparison-AEO vs. Natural Gas Markets, LBNL-55701, 02/2005
  - Dale, Larry, Millstein, Dev, Coughlin, Katie, Van Buskirk, Robert, Rosenquist, Gregory, Lekov, Alex, Bhuyan, Sanjib. An Analysis of Price Determination and Markups in the Air-Conditioning and Heating Equipment Industry, LBNL-52791, 01/2004
  - Lutz, James, Dunham-Whitehead, Camilla, Lekov, Alex, McMahon, James, “Modeling energy consumption of residential furnaces and boilers in U.S. homes”, LBNL-53924, 02/01/2004
  - Biermayer, Peter, Lutz, James, Lekov, Alex, Measurement of airflow in residential furnaces, LBNL-53947, 01/24/2004
  - Lutz, James, Lekov, Alex, Dunham-Whitehead, Camilla, Chan, Peter, Meyers, Steve, McMahon, James, Life-cycle cost analysis of energy efficiency design options for residential furnaces and boilers, LBNL-53950, 01/20/2004

U.S. Department of Energy
Energy Efficiency and Renewable Energy

U.S. Department of Energy
Appliance Standards Peer Review

Shipments Analysis and National Impact Analysis

James McMahon

Lawrence Berkeley National Laboratory

June 28, 2005

U.S. Department of Energy
Energy Efficiency and Renewable Energy

OUTLINE:
National Impact Analysis, including Shipments Analysis

- **REQUIREMENTS and OBJECTIVES**
- **TECHNICAL APPROACH**
  - Estimate annual shipments with and without new efficiency standards
  - Analyze national energy savings and net present value
- **PROJECT TEAM**
- **ACCOMPLISHMENTS and STATUS**

2

Requirements

- **EPCA directs DOE to consider a number of factors when specifying a new appliance efficiency standard, including**
  - Economic impact on manufacturers and consumers
  - Total projected energy savings, and
  - Need for national energy conservation
- **Total projected amount of energy savings resulting from a standard is one such factor**
  - Shipments: Quantify changes in product shipments due to potential new energy efficiency standards
  - National Impacts: Determine the projected national energy savings and net present value

3

Objectives

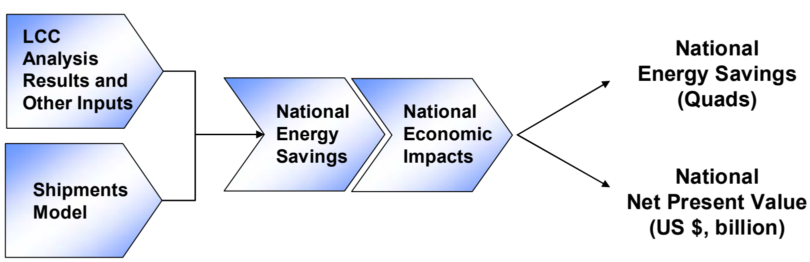
- **Shipments and National Impact Analyses are conducted to determine effects of appliance standards on the Nation**
  - Ensures that the Building Technologies Program fulfills EPCA's requirements and fulfills goals of improving building and equipment efficiency
  - Satisfies the legislative mandate for DOE to analyze appliance efficiency standards
  - Addresses legislative criteria that a standard must provide the Nation with *significant energy savings* and be *economically justified*

4

Technical Approach

- **Shipments Analysis**
  - Project the new appliance shipments under a proposed standard
  - Track the stock of appliances by vintage over the time frame of the analysis
- **National Impact Analysis**
  - Calculate projected national energy savings (annual and cumulative)
  - Calculate national consumer economic impacts (i.e., net present value) of possible new energy efficiency standards

Process Flowchart



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Energy Efficiency and Renewable Energy

Overview

- **Purpose**
  - Project new equipment shipments under possible standards
  - Track the stock of equipment, by vintage, over the analysis period
- **The life cycle of equipment is modeled as a "birth–death" process in which equipment changes from one state to another**
  - New equipment is purchased and shipped to the site where it is installed
  - Equipment operates for some number of years
  - The equipment is retired
- **The model is probabilistic**
  - The change from one state to another is determined by a probability function
- **A new purchase is influenced by several factors**
  - Economics (e.g. equipment price and operating costs)
  - Equipment failures
  - New building construction rates
- **The model is calibrated to historical shipments and market saturation data**

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Shipments Analysis

Shipments Analysis – Data Inputs for Commercial Appliances

Input	Data Source/Description
Commercial Building Data	
Forecasted New Construction	U.S. DOE-EIA, *Annual Energy Outlook*
Historical New Construction	U.S. Census Bureau, *Statistical Abstract of the United States*
Forecasted Stock	U.S. DOE-EIA, *Annual Energy Outlook*
Historical Stock	U.S. DOE, *Commercial Building Energy Consumption Survey (CBECS)*
Market Saturation Data (percent of floor space with appliance) and Replacements	
Historical Saturation	Trade Association or U.S. Census Bureau, *Current Industrial Reports*
Replacements driven by Appliance Lifetime	From Life-Cycle Cost Analysis
Purchase Decision Data	
Total Installed Cost, Annual Operating Cost	From Life-Cycle Cost Analysis
Business Income	Building Owners and Managers Association (BOMA) International, *Historical Experience Exchange Reports*
Calibration Data	
Historical Shipments	Trade Association or U.S. Census Bureau, *Current Industrial Reports*

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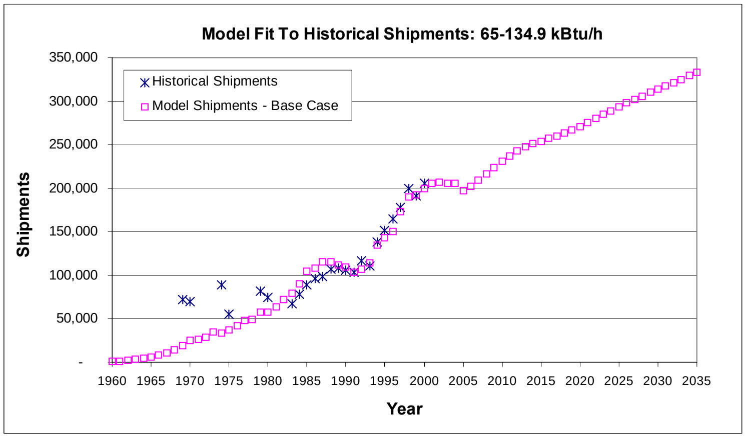
RESULTS WITHOUT NEW STANDARDS

Example: Commercial Unitary Air Conditioners, ≥65,000 Btu/h to <135,000 Btu/h



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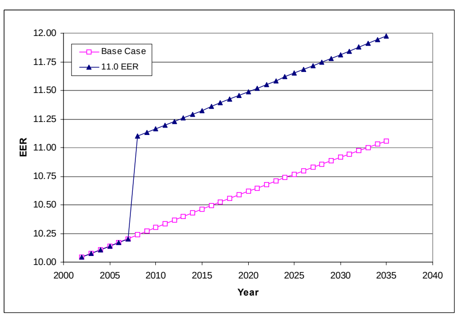
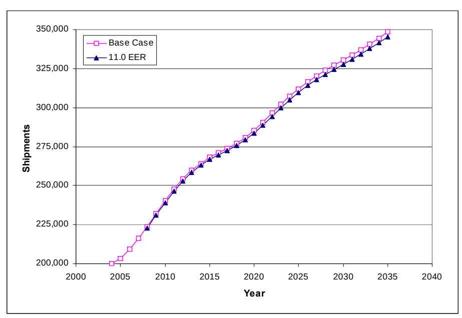
U.S. Department of Energy
Energy Efficiency and Renewable Energy
Shipments Analysis

RESULTS WITH STANDARDS

Example: Commercial Unitary Air Conditioners, ≥65,000 Btu/h to <135,000 Btu/h, 11 EER



- **Appliance shipment-weighted average efficiency under the standards (11 EER) case is assumed to increase in the year the standard becomes effective and grow at the same rate as the base case**



- **Shipments under the standards (11 EER) case are forecasted to drop due to the increased purchase price of more efficient appliances**

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Differences between LCC and National Impact Analyses

Life-Cycle Costs

- **Static difference as if all equipment purchases are made in the same year**
- **Net LCC savings (or costs) from statistically representative cross-section of individual consumers**

National Impact

- **Difference between two time-dynamic scenarios –without and with new energy efficiency standards**
- **Aggregate national impacts**
  - Energy savings
  - Net Present Value

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Energy Efficiency and Renewable Energy

Overview

- **Utilize a shipments model to estimate the total stock of units in service in any year**
- **Utilize the LCC analysis to estimate the average cost and energy use per unit in any given year**
- **Aggregate the costs and energy use, by vintage, for number of years in the analysis period (typically decades)**
- **Account for energy at the source of production not the site of consumption**
- **Account for the time value of money using discount rate**
- **Implement in MS Excel® spreadsheet**

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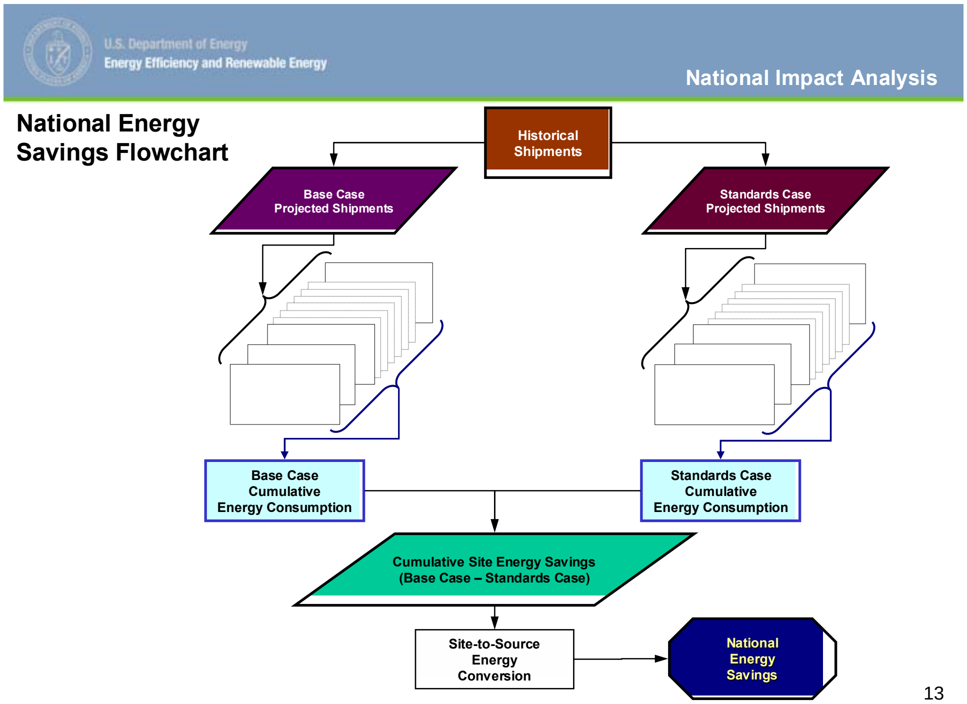
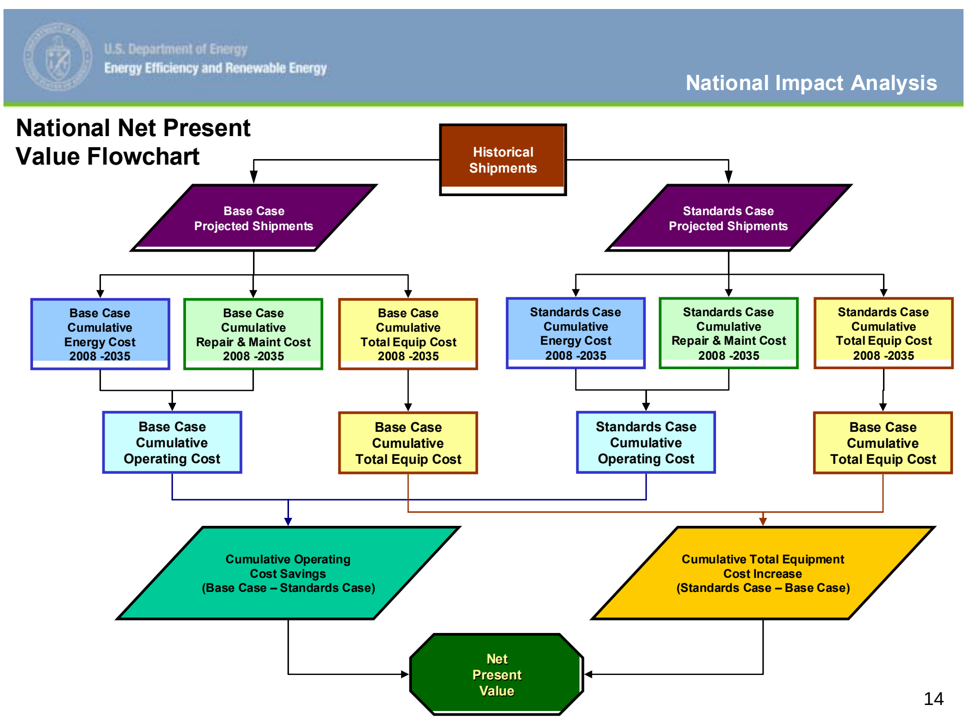

U.S. Department of Energy
Energy Efficiency and Renewable Energy
National Impact Analysis
National Energy Savings Flowchart
Historical Shipments
Base Case Projected Shipments
Standards Case Projected Shipments
Base Case Cumulative Energy Consumption
Standards Case Cumulative Energy Consumption
Cumulative Site Energy Savings (Base Case – Standards Case)
Site-to-Source Energy Conversion
National Energy Savings
13


U.S. Department of Energy
Energy Efficiency and Renewable Energy
National Impact Analysis
National Net Present Value Flowchart
Historical Shipments
Base Case Projected Shipments
Standards Case Projected Shipments
Base Case Cumulative Energy Cost 2008 -2035
Base Case Cumulative Repair & Maint Cost 2008 -2035
Base Case Cumulative Total Equip Cost 2008 -2035
Standards Case Cumulative Energy Cost 2008 -2035
Standards Case Cumulative Repair & Maint Cost 2008 -2035
Standards Case Cumulative Total Equip Cost 2008 -2035
Base Case Cumulative Operating Cost
Base Case Cumulative Total Equip Cost
Standards Case Cumulative Operating Cost
Base Case Cumulative Total Equip Cost
Cumulative Operating Cost Savings (Base Case – Standards Case)
Cumulative Total Equipment Cost Increase (Standards Case – Base Case)
Net Present Value
14

Data Inputs

- **Total Installed Cost**
  - Average per unit values as a function of efficiency level taken from LCC analysis
  - Future values are adjusted with efficiency trends
- **Repair and Maintenance Costs**
  - Average per unit values as a function of efficiency level taken from LCC analysis
  - Future values are adjusted with efficiency trends
- **Annual Energy Use**
  - Weighted-average per unit values as a function of efficiency level taken from LCC analysis
  - Future values are adjusted with efficiency trends
- **Efficiency Trends**
  - Developed for the base case (without standards) and each standards case
  - Future trends based upon historical shipment-weighted efficiency data
- **Energy Prices**
  - Weighted-average marginal prices taken from LCC analysis
  - Future marginal prices are adjusted according to trend forecasted by the *Annual Energy Outlook*
- **Electricity Site-to-Source Conversion Factors**
  - Conversion factors forecasted by *Annual Energy Outlook*
  - Factors vary annually and account for generation, distribution, and transmission losses
- **Discount Rate**
  - 7% and 3% real from OMB's Regulatory Analysis Guideline A-4
- **Present Year**
  - Future expenses are discounted to a specified year

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National Impact Analysis: Spreadsheet

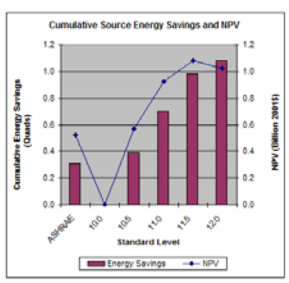
Summary of Results -- National Energy Savings and National Net Present Value for Commercial Unitary Air Conditioners (July 2003)

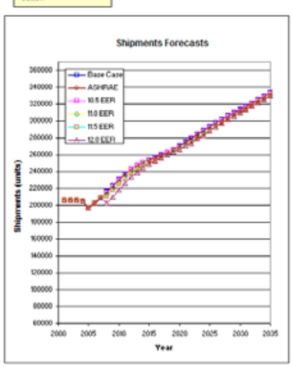
User defined inputs

Equipment Class	65-135
Max Tech	12.0 EER
Economic Growth	Reference
Discount Rate	7.0%

To Re-Run the model with user selected inputs, press the green button → Update Values

		Standard Level					
	Base	ASHRAE	10.0	10.5	11.0	11.5	12.0
Cumulative Shipments (2008-2035)	7,798,287	7,783,771	-	7,774,447	7,735,264	7,672,629	7,632,366
Shipments % Change		99.81%	0.00%	99.69%	99.19%	98.39%	97.87%
Equipment Cost Difference ($billions)		$ (0.23)	$ -	$ (0.27)	$ (0.57)	$ (0.99)	$ (1.26)
Operating Cost Savings ($billions)		$ 0.75	$ -	$ 0.84	$ 1.50	$ 2.06	$ 2.28
NPV Value ($billions)		$ 0.52	$ -	$ 0.57	$ 0.93	$ 1.08	$ 1.02
Cumulative Energy Savings (Quads)		0.31	0.00	0.39	0.70	0.98	1.08





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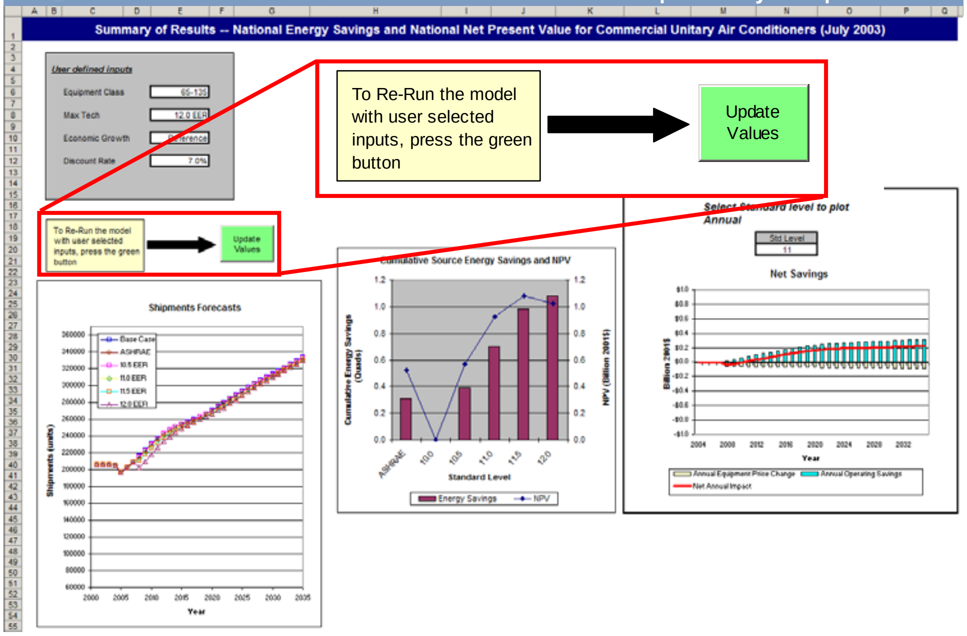
National Impact Analysis: Spreadsheet

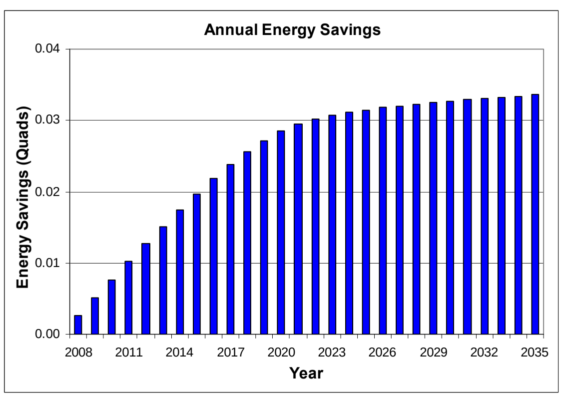


U.S. Department of Energy
Energy Efficiency and Renewable Energy

National Impact Analysis: Results

National Energy Savings

Example: Commercial Unitary A/C (≥65,000 Btu/h to <135,000 Btu/h)
11.0 EER compared to 10.1 EER (base case)



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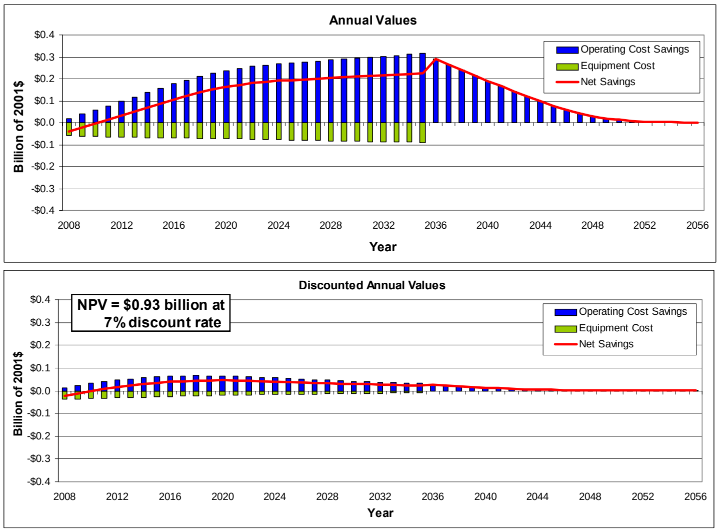
Energy Efficiency and Renewable Energy

National Impact Analysis: Results

Net Present Value Results

Example: Commercial Unitary A/C, ≥65,000 Btu/h to <135,000 Btu/h, 11.0 EER



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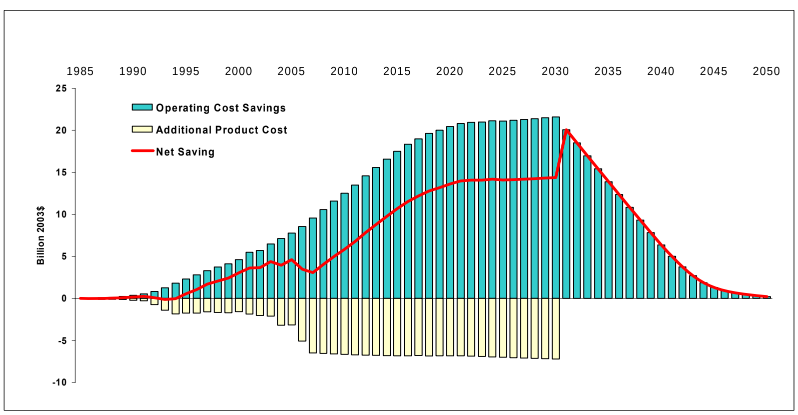
Energy Efficiency and Renewable Energy

National Impact Analysis: Results

Annual Consumer Impacts of DOE Residential Appliance Standards – All Products (not discounted)



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Analysis Team

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National Impact Analysis

Staff Resources

- **Distribution Transformers**
  - FY 2001-2004 funding and staff levels reflect effort to complete ANOPR

	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	Total
Key Personnel (person-months)						
Jim McMahon, PI	0.5	0.5	0.5	0.5	0.5	2.3
John Stoops, Project Manager	2.7	2.7	2.7	2.7	3.0	13.8
Robert Van Buskirk, Analyst	2.0	2.0	2.0	2.0	1.3	9.2
Maithili Iyer, Analyst	5.4	5.4	5.4	5.4	5.4	27.0
Larry Dale, Analyst	0.1	0.1	0.1	0.1	0.1	0.5
Stuart Chaitkin, Analyst	1.8	1.8	1.8	1.8	2.0	9.2
Laura Van Wie McGrory, Analyst	0.0	0.0	0.0	0.8	0.9	1.7
Chris Bolduc, Analyst	0.7	0.7	0.7	0.7	1.2	4.1
Karen Olson, Analyst	0.4	0.4	0.4	0.4	0.4	1.8
Terry Chan, Analyst	0.5	0.5	0.5	0.5	0.6	2.8
Diana Morris, Admin. Support	0.8	0.8	0.8	0.8	0.9	4.2
Total (person-months)	**14.9**	**14.9**	**14.9**	**15.7**	**16.3**	**76.6**

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U.S. Department of Energy
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National Impact Analysis

Staff Resources

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  - FY 2001-2004 funding and staff levels reflect effort to complete ANOPR

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Key Personnel (person-months)						
Jim McMahon, PI	0.5	0.5	0.5	0.5	0.5	2.6
Alex Lekov, Project Manager	3.1	3.1	3.1	3.1	2.9	15.2
Jim Lutz, Analyst	1.9	1.9	1.9	1.9	2.7	9.7
Michael McNeil, Analyst	3.2	3.2	3.2	3.2	3.2	16.2
Larry Dale, Analyst	0.1	0.1	0.1	0.1	0.1	0.5
Peter Chan, Analyst	0.6	0.6	0.6	0.6	0.0	2.5
Victor Franco, Analyst	2.7	2.7	2.7	2.7	2.7	13.5
Gabrielle Wong-Parodi, Analyst	2.0	2.0	2.0	2.0	2.0	10.2
Laura Van Wie McGrory, Analyst	0.0	0.0	0.0	0.9	0.9	1.8
Camilla Whitehead, Analyst	0.9	0.9	0.9	0.9	1.0	4.5
Steve Meyers, Analyst	0.6	0.6	0.6	0.6	0.5	2.8
Terry Chan, Analyst	0.6	0.6	0.6	0.6	0.6	3.1
Diana Morris, Admin. Support	1.0	1.0	1.0	1.0	0.9	4.9
Total (person-months)	**17.2**	**17.2**	**17.2**	**18.2**	**17.6**	**87.4**

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Accomplishments and Status

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- **Residential Furnaces and Boilers**
  - Framework Document - July 17, 2001
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Energy Efficiency and Renewable Energy

DOE Primary Technical Products

- **Distribution Transformers**
  - U.S. Department of Energy-Office of Energy Efficiency and Renewable Energy, *Technical Support Document: Energy Efficiency Program for Commercial and Industrial Equipment: Electrical Distribution Transformers*, July, 2004. Washington, DC.
  - U.S. Department of Energy-Office of Energy Efficiency and Renewable Energy, ANOPR Analytical Spreadsheets, Life-Cycle Cost Calculations by Design Line, October, 2004. Washington, DC.

- **Residential Furnaces and Boilers**
  - U.S. Department of Energy-Office of Energy Efficiency and Renewable Energy, *Technical Support Document: Energy Efficiency Program for Consumer Products: Energy Conservation Standards for Residential Furnaces and Boilers*, September, 2004. Washington, DC.
  - U.S. Department of Energy-Office of Energy Efficiency and Renewable Energy, Residential Furnaces and Boilers ANOPR Analytical Tools, October, 2004. Washington, DC.

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Energy Efficiency and Renewable Energy

National Impact Analysis

- **Associated Publications**
  - Wong-Parodi, Gabrielle, Lekov, Alex, Dale, Larry. Natural Gas Prices Forecast Comparison-AEO vs. Natural Gas Markets, LBNL-55701, 02/2005
  - Dale, Larry, Millstein, Dev, Coughlin, Katie, Van Buskirk, Robert, Rosenquist, Gregory, Lekov, Alex, Bhuyan, Sanjib. An Analysis of Price Determination and Markups in the Air-Conditioning and Heating Equipment Industry, LBNL-52791, 01/2004
  - Lutz, James, Dunham-Whitehead, Camilla, Lekov, Alex, McMahon, James, "Modeling energy consumption of residential furnaces and boilers in U.S. homes", LBNL-53924, 02/01/2004
  - Biermayer, Peter, Lutz, James, Lekov, Alex, Measurement of airflow in residential furnaces, LBNL-53947, 01/24/2004
  - Lutz, James, Lekov, Alex, Dunham-Whitehead, Camilla, Chan, Peter, Meyers, Steve, McMahon, James, Life-cycle cost analysis of energy efficiency design options for residential furnaces and boilers, LBNL-53950, 01/20/2004 Residential Furnaces and Boilers

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U.S. DOE Energy Conservation Standards

Manufacturer Impact Analyses

Principal investigator
Michael C. Rivest
Navigant Consulting, Inc.

June 28, 2005

U.S. Department of Energy
Energy Efficiency and Renewable Energy

Agenda

This presentation is organized into the following key areas:

1. Objectives and Strategic Relevance
2. Technical Approach
3. Resources and Schedules
4. Results

1 Objectives and Strategic Relevance

2 Technical Approach

3 Resources and Schedules

4 Results

The goal of the Manufacturer Impact Analysis is to qualitatively and quantitatively assess the impacts on manufacturers of potential energy efficiency standards.

Purpose

» To assess the impacts of standards on manufacturers
» To identify and estimate impacts on manufacturer sub-groups that may be more severely impacted than the industry as a whole
» To examine the impact of cumulative regulatory burdens on the industry

Method

» Analyze industry cash flow and net present value through use of the Government Regulatory Impact Model (GRIM)
» Interview manufacturers to refine inputs to the GRIM, develop sub-group analyses, and address qualitative issues

Output

» Industry Net Present Value impacts
» Sub-group Net Present Value impacts
» Other impacts

The Manufacturers Impact Analysis (MIA) fulfils a legislative requirement to determine if a proposed standard is economically justified.

» The Energy Policy Conservation Act (EPCA) provides seven factors to be evaluated in determining whether an appliance efficiency standard [energy conservation standard] is justified. (42 U.S.C. 6313(a)(6)(B)(i)) Two of these factors require the DOE to consider the economic impact of standards on manufacturers and the impacts of any lessening of competition in the industry. Both of these factors are assessed through the manufacturer impact analysis.

» In September, 1995, the Department announced a formal effort to consider further improvements to the process used to develop appliance efficiency standards. The Department called on energy efficiency groups, manufacturers, trade associations, state agencies, utilities, and other interested parties to provide input to this effort.

» As a result of this combined effort, the Department published Procedures, Interpretations and Policies for Consideration of New or Revised Energy Conservation Standards for Consumer Products (the “process rule”), 10 CFR 430, Subpart C, Appendix A. The process rule contains principles for the analysis of regulatory impacts on manufacturers.

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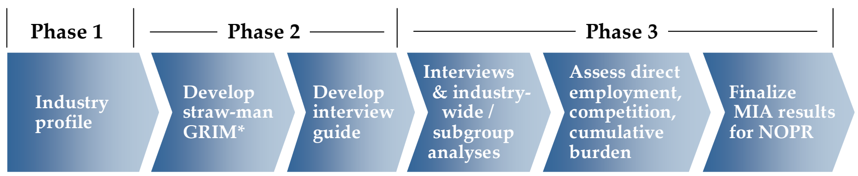
Overall Process

The MIA consists of three main phases.



* Government Regulatory Impact Model (GRIM)

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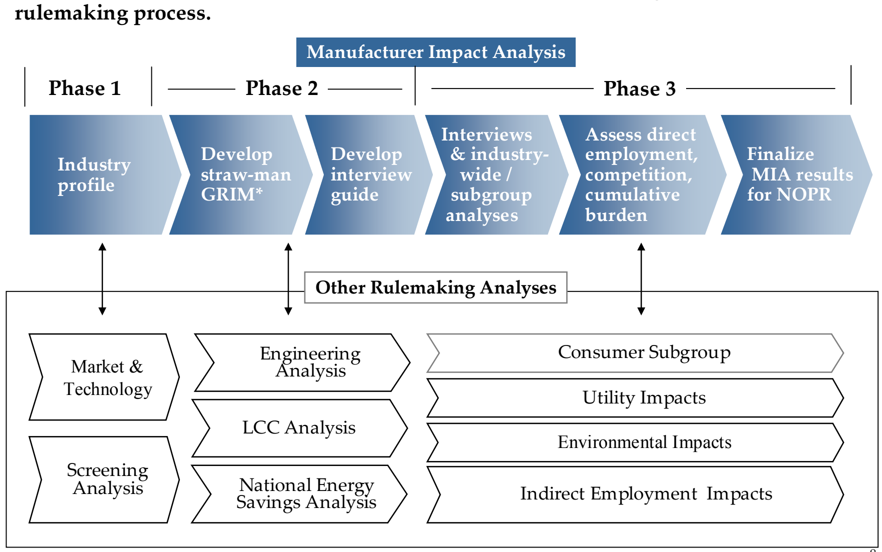
Overall Process (2)

The MIA is both concurrent and coordinated with activities throughout the rulemaking process.



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Methodology

In the July 1996 Process Rule, the Department committed to a detailed review of the Manufacturer Impact Analyses methodologies. The new methodology must:

- ☑ Provide for early stakeholder input.
- ☑ Utilize an annual cash flow approach to determine quantitative impacts, including an assessment of short-term cost and capital requirements.
- ☑ Develop estimates of critical variables (with input from interested parties) drawing on multiple sources, both quantitative and qualitative.
- ☑ Report the distribution of impacts on manufacturers.
- ☑ Use models that are easy to understand and account for uncertainty.
- ☑ Consider the cumulative impacts of regulation.
- ☑ Consider the impacts on manufacturing capacity, plant closures, and loss of capital investment.

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Methodology (2)

To explore the economic and competitive issues, several questions are asked in the MIA.

- What impacts will standards have on...
  - Industry cash flows and net present value?
  - Product flow through distribution channels?
  - Manufacturing capacity?
  - Industry employment levels?
  - Competition?
- What products or subgroups may be particularly sensitive to impacts of new standards?
- What other regulations contribute to a cumulative regulatory burden on manufacturers, and what is their combined impact?
- Should the Department consider other topics beside competition, employment, capacity utilization and cumulative burden?

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The industry profile consists of two main components, industry characterization and issue identification.

Industry Characterization	Issue Identification
» Evaluation of current and past industry structure and market characteristics (e.g. market share, number of firms, fiscal health) » Produce an industry profile report with aggregated findings and characteristics	» Meetings are held to identify critical issues that require special consideration in the MIA, for example: » Types or groups of manufacturers » Access to technology » Potential regulatory scenarios

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To serve as a common source of information for participants in the rulemaking, DOE profiles the industry.

» Identify producers and other key market participants influencing products, prices, and sales

» Identify manufacturer characteristics (i.e. niche vs. full line)

» Show time-series on shipments, prices, features, energy efficiency

» Show time-series on productivity of labor, capital and materials

» List firms and their historical market shares

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Phase I >> Industry Characterization (2)

During the Industry Characterization, DOE collects financial and market information

» Industry reports

» Company annual reports and websites

» Trade journals

» U.S. Census Bureau

» SEC 10-K form filings

» ANOPR information: manufacturer production costs, markups and manufacturer selling prices, shipments

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Phase I >> Issues Identification Workshop

Before beginning detailed impact analyses, DOE identifies manufacturer impact issues at both the Framework and ANOPR Workshops, and participants are invited to:

» Identify sub-groups of manufacturers so that the analysis may be structured to capture distributions of impacts

» Identify issues of access to technology

» Review information requirements and information gathering methods

» Identify any special analytical tools needed to perform the analysis

» Adapt the generic MIA methodology

» Establish a timeline for conducting the analysis

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Phase II >> Overview

In Phase 2, the analysis conducted by the DOE is quantified using the Government Regulatory Impact Model (GRIM). This financial modeling tool estimates the impacts of standards and other regulations on manufacturers.

» The GRIM was developed by Arthur D. Little with funding from and the participation of GAMA, ARI and AHAM.

» Based on discounted cash flow analysis

» Creates full computations of cash flow for both base case (absence of standards) and standards case

» Computes Industry Values (NPV) for both scenarios

» Offers numeric and graphical comparisons

» Facilitates communicating anticipated impacts to all stakeholders

» Allows aggregation of impacts on individual companies

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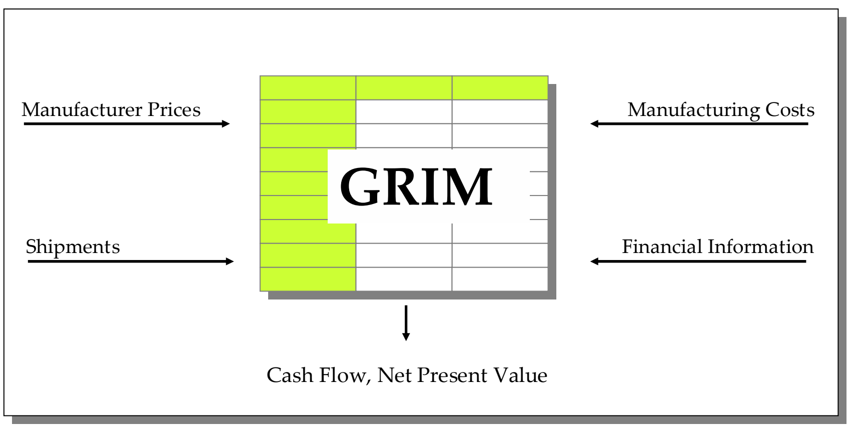
Phase II >> GRIM Description

GRIM uses four key inputs: manufacturer prices, manufacturing costs, shipments, and financial information to calculate cash flows used for arriving at the industry value.



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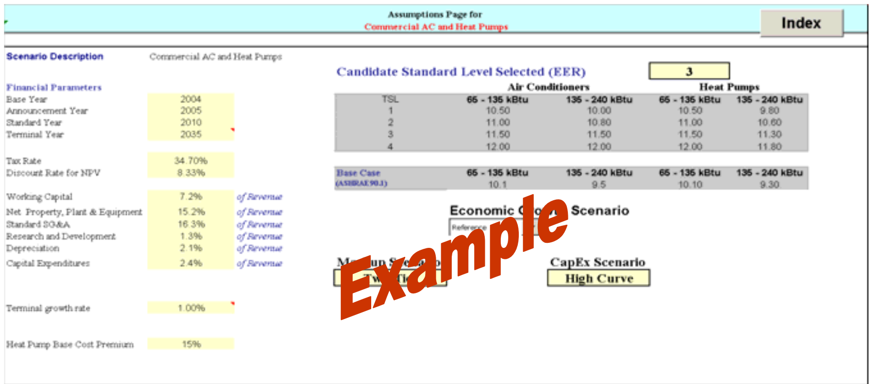
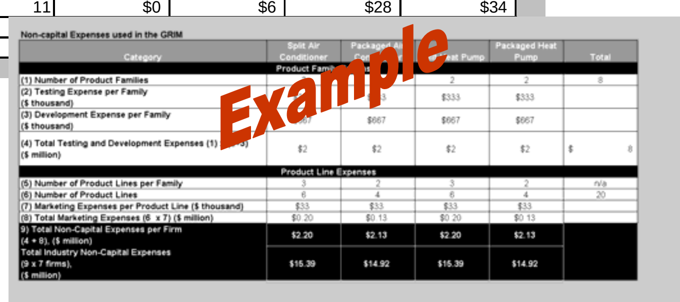
GRIM's main interface allows users to change certain key inputs and assumptions including most of the financial parameters, economic growth scenarios, and markups.



Among the key inputs to the GRIM are the capital and non-capital expenses related to complying with new energy efficiency standards.

Capital Expenditures

Standard Level (SEER)	Capacity Additions	Warehouse Additions	New Tooling	Total
Capital Expenditures per Company				
11	$0.00	$0.90	$4.00	$4.90
12	$6.00	$4.40	$4.00	$14.40
13	$14.50	$6.00	$4.00	$24.50
Resulting Capital Expenditures for the Industry (seven companies)				
11	$0	$6	$28	$34



Non-capital Expenses used in the GRIM

Category	Split Air Conditioner	Packaged Ai[illegible]	[illegible]eat Pump	Packaged Heat Pump	Total
Product Fam[illegible]					
(1) Number of Product Families	[illegible]	[illegible]	2	2	8
(2) Testing Expense per Family ($ thousand)	[illegible]	[illegible]	$333	$333	
(3) Development Expense per Family ($ thousand)	[illegible]	$667	$667	$667	
(4) Total Testing and Development Expenses (1) [illegible] ($ million)	$2	$2	$2	$2	$ 8
Product Line Expenses					
(5) Number of Product Lines per Family	3	2	3	2	n/a
(6) Number of Product Lines	6	4	6	4	20
(7) Marketing Expenses per Product Line ($ thousand)	$33	$33	$33	$33	
(8) Total Marketing Expenses (6 x 7) ($ million)	$0.20	$0.13	$0.20	$0.13	
9) Total Non-Capital Expenses per Firm (4 + 8), ($ million)	$2.20	$2.13	$2.20	$2.13	
Total Industry Non-Capital Expenses (9 x 7 firms), ($ million)	$15.39	$14.92	$15.39	$14.92	

The GRIM models the industry's income and cash-flow statements under different Trial Standard Levels (TSL)

Non-Weatherized Gas Furnaces														
BASE CASE SCENARIO			Base Year 2004	2005	2006	Announcement Year 2007	2008	2009	2010	2011	2012	2013	2014	Standard Year 2015
Income Statement (mln)														
Unit Sales			2.465	2.388	2.372	2.403	2.419	2.434	2.480	2.541	2.577	2.633	2.705	2.753
Revenues			$ 1,505	$ 1,458	$ 1,448	$ 1,467	$ 1,477	$ 1,486	$ 1,514	$ 1,552	$ 1,574	$ 1,607	$ 1,652	$ 1,681
Cost of Sales														
	Labor	10.5%	$ 159	$ 154	$ 153	$ 155	$ 156	$ 157	$ 160	$ 164	$ 166	$ 169	$ 174	$ 177
	Material	52.2%	$ 786	$ 761	$ 756	$ 766	$ 771	$ 776	$ 790	$ 810	$ 821	$ 839	$ 862	$ 877
	Overhead	4.3%	$ 65	$ 63	$ 62	$ 63	$ 64	$ 64	$ 65	$ 67	$ 68	$ 69	$ 71	$ 72
	Freight	3.6%	$ 54	$ 53	$ 52	$ 53	$ 53	$ 54	$ 55	$ 56	$ 57	$ 58	$ 60	$ 61
	Depreciation		$ 26	$ 25	$ 25	$ 26	$ 26	$ 26	$ 26	$ 27	$ 27	$ 28	$ 29	$ 29
Selling, General and Administrative														
	Standard SG&A	18.1%	$ 272	$ 263	$ 261	$ 265	$ 267	$ [illegible]	$ 273	$ 280	$ 284	$ 290	$ 298	$ 303
	R&D	1.4%	$ 20	$ 20	$ 20	$ 20	$ 20	$ [illegible]	[illegible] 20	$ 21	$ 21	$ 22	$ 22	$ 23
	Product Conversion Expense		$ -	$ -	$ -	$ -	$ -	$ [illegible]	[illegible]	$ -	$ -	$ -	$ -	$ -
Profit Before Tax		8.2%	$ 123	$ 120	$ 119	$ 120	[illegible]	[illegible]	$ 124	$ 127	$ 129	$ 132	$ 135	$ 138
			8.2%	8.2%	[illegible]	[illegible]	[illegible]	[illegible]	8.2%	8.2%	8.2%	8.2%	8.2%	8.2%
Taxes			$ 46	$ 45	[illegible]	[illegible]	[illegible]	46	$ 47	$ 48	$ 48	$ 49	$ 51	$ 52
Net Income before Financing			$ 77	$ 75	[illegible]	75	$ 76	$ 76	$ 78	$ 80	$ 81	$ 82	$ 85	$ 86
Cash Flow Statement														
	Net Income		$ 77	$ 75	$ 74	$ 75	$ 76	$ 76	$ 78	$ 80	$ 81	$ 82	$ 85	$ 86
	Depreciation		$ 26	$ 25	$ 25	$ 26	$ 26	$ 26	$ 26	$ 27	$ 27	$ 28	$ 29	$ 29
	Change in Working Capital		$ 9	$ 4	$ 1	$ (2)	$ (1)	$ (1)	$ (2)	$ (3)	$ (2)	$ (3)	$ (4)	$ (3)
Cash Flows from Operations			$ 112	$ 104	$ 100	$ 99	$ 101	$ 101	$ 102	$ 103	$ 106	$ 107	$ 110	$ 113
	Ordinary Capital Expenditures		$ (29)	$ (28)	$ (28)	$ (29)	$ (29)	$ (29)	$ (30)	$ (30)	$ (31)	$ (31)	$ (32)	$ (33)
	Conversion Capital Expenditures		$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Cash Used In Investment			$ (29)	$ (28)	$ (28)	$ (29)	$ (29)	$ (29)	$ (30)	$ (30)	$ (31)	$ (31)	$ (32)	$ (33)
Net Cash Flow			$ 83	$ 76	$ 72	$ 70	$ 72	$ 72	$ 72	$ 73	$ 75	$ 76	$ 77	$ 80
Terminal Value			$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Present Value Factor			0.93	0.87	0.81	0.75	0.70	0.65	0.60	0.56	0.52	0.49	0.45	0.42
Discounted Cash Flow			$ 77	$ 66	$ 58	$ 53	$ 50	$ 47	$ 43	$ 41	$ 39	$ 37	$ 35	$ 34
Industry Value thru 2038		$ 1,164												

Example

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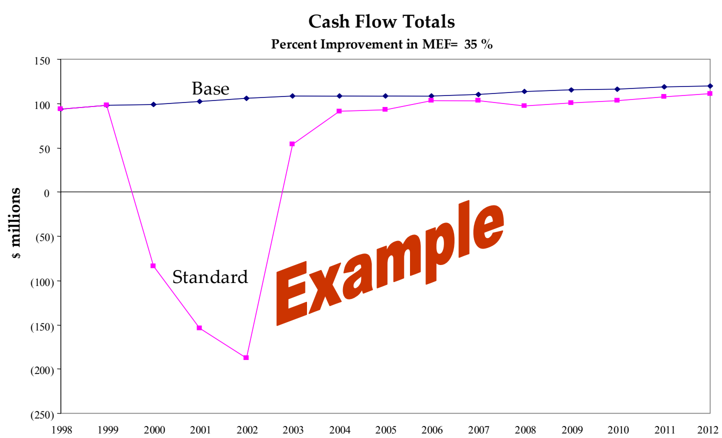
Phase II >> GRIM Description

The Manufacturer Impact Analysis estimates the cash flow impacts of increased equipment efficiency levels on manufacturers



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Phase II >> Strawman GRIM

A "strawman" GRIM provides a starting point for discussion of impacts

- Forecasted manufacturer prices are consistent with the Life-cycle cost analysis.
- Shipment forecasts are based on the National Energy Savings analysis.
- Manufacturing cost estimates are made with data acquired from the engineering analysis.
- Financial information (e.g., tax rate, working capital, depreciation, etc.) from manufacturers' 10-K statements and other publicly available industry statistics (e.g., S&P Reports, ValueLine Industry Statistics). These data are derived in part from the Industry Profile completed in Phase 1 of the MIA.

Phase II >> Develop Interview Guide

A critical aspect of the MIA involves interviews with manufacturers. An interview guide is sent to manufacturers in preparation for Phase III. Interview topics include:

- Engineering Analysis
- Shipments model
- Cost structure and financial parameters
- Conversion costs (capital expenditures, tooling, R&D, testing)
- Impact of other regulations / cumulative burden
- Direct employment impacts
- Import / Export issues
- Consolidation / competitive impacts
- Replacement parts or refurbishments
- Impact of the standard's effective date
- Other topics important to manufacturers

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Phase III >> Manufacturer Interviews

Interviews with manufacturers on behalf of DOE poses challenges

» Expected timeframe is relatively short.
» Time and personnel commitment for manufacturers (industry-wide GRIM, GRIM assumptions, subgroup analysis discussion)
» Confidentiality agreements

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Phase III >> Competitive Impacts Assessment

DOE provides input to the Department of Justice (DOJ)

» Competitive Analysis focuses on assessing the impacts to smaller, significant manufacturers
» DOJ participated in drafting questions used in past and present manufacturer interviews
» Questions pertain to an assessment of the likeliness of increased concentration levels and other market conditions that could lead to uncompetitive pricing behavior
  » Asymmetrical cost increases to some manufacturers
  » Increased proportion of fixed costs potentially increasing business risk
  » Barriers to market entry (proprietary technologies, etc.)

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Phase III >> Manufacturing Capacity Impacts

One of the significant outcomes of new standards could be the consequential obsolescence of existing manufacturing assets, including tooling and investment. The manufacturer interview guide addresses a series of issues to help identify impacts on manufacturing capacity, specifically:

» capacity utilization and plant location decisions in the U.S. and North America with and without a standard level;

» the ability of manufacturers to upgrade or remodel existing facilities to accommodate the new requirements;

» the nature and value of stranded assets, if any; and

» estimates for any one-time restructuring and other charges, where applicable.

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Phase III >> Employment Impacts

The impact of new energy-efficiency standards on employment is an important consideration in the rulemaking process, manufactures interviews usually focus on:

» current employment levels at each of their production facilities;

» expected future employment levels with and without a standard; and

» differences in workforce skills and issues related to the retraining of employees.

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Results

The results of the MIA are summarized in a few key financial metrics that compared the impacts between different proposed energy efficiency levels and the selected base-case.

TSL	Capital Investments ($ million)	Product Conversion Costs ($ million)	Industry Net Present Value ($ million)	% Change in INPV
Base-case	$0	$0	$450	
TSL 1	$20	$18	$420	-6.7%
TSL 2	$90	$80	$380	-15.6%
TSL 3	$120	$230	$275	-38.9%

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Energy Efficiency and Renewable Energy

Agenda

1 Objectives and Strategic Relevance

2 Technical Approach

3 **Resources and Schedules**

4 Results

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Energy Efficiency and Renewable Energy

Analysis Team

Ron Lewis

DOE

CUAC	Res. Furnaces & Boilers	Dist. Transformers
Jim Raba	Mohammed Khan	Antonio Bouza

NCI

Group Management

Mike Rivest
Principal Investigator/Group Leader

Mike Scholand
Management/Quality Control

Product Manager

Aris Marantan CUAC	**Aris Marantan** **Graham Stevens** Res. F&B	**Barclay Gibbs** Distribution Transformers

Cross-Cutting Support

Barclay Gibbs	Analytical Methodology
Graham Stevens	Manufacturing Cost Estimation
Federico Garcia-Lopez	Financial Modeling

Cross-Cutting Rulemaking Oversight

Ed Levy Legal and Regulatory	Ed Barbour Cross-cutting Analysis	Mike Scholand Quality Control

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Schedule

Distribution Transformers Schedule

» Initiation Date: November 1, 2000

» Dates of Intermediate Phase Completions or Go/No-Go Points: Advance Notice of Proposed Rulemaking (ANOPR) published July 29, 2004; ANOPR Public Meeting on September 28, 2004; ANOPR Comment Period ended November 9, 2004.

» Original Expected Completion Date: "The Regulatory Plan and the Unified Agenda of Federal Regulatory and Deregulatory Actions" (69 FR 72712-72713) (commonly referred to as the *Regulatory Agenda*) calls for the Notice of Proposed Rulemaking (NOPR) to be published in September, 2006. It is scheduled to be published in September, 2006.

» The Regulatory Agenda calls for a Technical Support Document (TSD) to be reviewed by the Department by September, 2005.

» The Regulatory Agenda calls for a Final Rule to be published by September, 2007.

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Schedule

Residential Furnaces and Boilers Schedule

» Initiation Date: July 17, 2001

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Agenda

1 Objectives and Strategic Relevance

2 Technical Approach

3 Resources and Schedules

4 **Results**

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Energy Efficiency and Renewable Energy

Accomplishments and Status

- **Distribution Transformers**
  - Framework Document – November 1, 2000
  - ANOPR Internet Webcast – August 10, 2004
  - ANOPR and TSD published - July 29, 2004
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Technical Documents

For both rules, major accomplishments are the publication of the Technical Support Document and the Analytical Spreadsheets that accompanied the ANOPR.

Distribution Transformers

- U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy, Technical Support Document: Energy Efficiency Program for Commercial and Industrial Equipment: Electrical Distribution Transformers, July, 2004. Washington, DC.
  <http://www.eere.energy.gov/buildings/appliance_standards/commercial/dist_trans_tsd_061404.html>

- U.S. Department of Energy-Office of Energy Efficiency and Renewable Energy, ANOPR Analytical Spreadsheets, ANOPR engineering analysis results spreadsheets for all 13 design lines, April 2004. Washington, DC.
  <http://www.eere.energy.gov/buildings/appliance_standards/commercial/distribution_transformers_spreadsheets.html>

Residential Furnaces and Boilers

- U.S. Department of Energy-Office of Energy Efficiency and Renewable Energy, Technical Support Document: Energy Efficiency Program for Consumer Products: Energy Conservation Standards for Residential Furnaces and Boilers, September, 2004. Washington, DC.
  <http://www.eere.energy.gov/buildings/appliance_standards/residential/furnaces_boilers_1113_r.html>

- U.S. Department of Energy-Office of Energy Efficiency and Renewable Energy, Residential Furnaces and Boilers ANOPR Analytical Tools, September, 2004. Washington, DC.
  <http://www.eere.energy.gov/buildings/appliance_standards/residential/furnace_boiler_draft_analysis.html>

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U.S. Department of Energy
Appliance Standards Peer Review

Utility Impact Analysis, Environmental Assessment, Employment Impact Analysis, and Regulatory Impact Analysis

James McMahon

Lawrence Berkeley National Laboratory

June 28, 2005

U.S. Department of Energy
Energy Efficiency and Renewable Energy

Requirements

- **DOE must perform a variety of "other" analyses to fulfill its regulatory requirements and ensure that all potential impacts of proposed standards have been considered**
- **These "other" analyses include:**
  - Environmental Assessment – Consider environmental effects of proposed standards; EPCA directs DOE to consider the need for national energy conservation which includes environmental benefits
  - Employment Impact Analysis: Analyze national employment impacts of proposed standards; DOE's Process Rule (61 FR 36974) directs DOE to consider employment impacts
  - Utility Impact Analysis: Analyze impacts on the electric and gas utility industries (e.g., peak impacts, new capacity requirements)
  - Regulatory Impact Analysis: Analyze national impacts of alternatives to mandatory energy efficiency standards: Under Executive Order 12866, DOE is required to perform a regulatory analysis; DOE's Process Rule commits DOE to explore non-regulatory alternatives to standards

Objective

- **Environmental Assessment, Employment Impact Analysis, Utility Impact Analysis, and Regulatory Impact Analysis are conducted to ensure that DOE has considered potential impacts of proposed standards**
- **Ensure that the Building Technologies Program fulfills EPCA's requirements and fulfills goals of improving building and equipment efficiency**
  - Helps satisfy the legislative mandate for DOE to analyze appliance efficiency standards

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Technical Approach

- **Environmental Assessment**
  - To report environmental impacts as a consequence of new energy efficiency standards, including changes in power plant emissions
- **Employment Impact Analysis**
  - To report net jobs created or eliminated nationally as a consequence of new energy efficiency standards
- **Utility Impact Analysis**
  - To investigate the effects on utilities from reduced energy sales and peak load demand due to potential standards
- **Regulatory Impact Analysis**
  - To investigate the national impacts due to non-regulatory alternatives compared with mandatory energy efficiency standards

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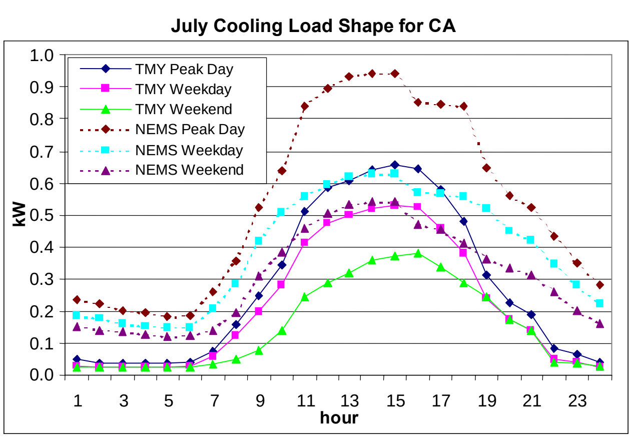
Environmental Assessment and Utility Impact Analysis

- **METHOD and INPUTS**
  - Install the Energy Information Administration's National Energy Modeling System (NEMS)
  - Confirm agreement between output from the installed model and results in *Annual Energy Outlook*
  - Analyze system and appliance end-use load shapes in NEMS to ensure proper coincidence between system and appliance loads
    - Replace NEMS load data if necessary
  - Input energy savings from possible standards as provided from the National Impact Analysis into NEMS
  - Run NEMS to calculate reductions in air-borne emissions and installed generation capacity
  - For fossil-fuel fired appliances, determine site emissions based on emission factors
- **OUTPUT – Environmental Assessment**
  - Estimate changes in national emissions of NO_x and CO_2
  - (As appropriate) Estimate emissions of CFCs, HCFCs
- **OUTPUT – Utility Impact Analysis**
  - Change in electricity sales and price by region (or natural gas)
  - Change in the mix of electricity generation
  - Change in new capacity construction

5

Environmental Assessment and Utility Impact Analysis

Comparison of NEMS and Typical Meteorological Year (TMY) July Commercial Cooling End-Use Loads



- TMY weather removes extreme temperature swings
- TMY summer (July) loads less peaky than NEMS loads, which are based on an actual weather year

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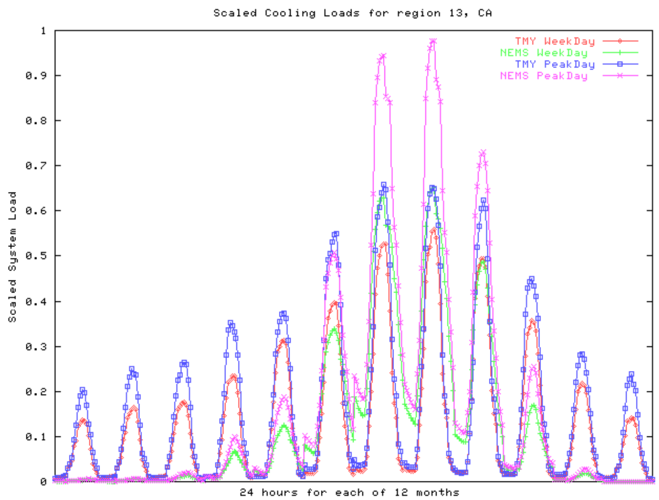
U.S. Department of Energy
Energy Efficiency and Renewable Energy

Environmental Assessment and Utility Impact Analysis

Environmental Assessment and Utility Impact Analysis

Comparison of NEMS and TMY Annual Commercial Cooling End-Use Loads



- Comparison of annual cooling loads reveals:
  - NEMS loads peakier in summer months with very small energy use in winter months
  - TMY loads although less peaky have energy use throughout the year
- TMY cooling loads are more realistic

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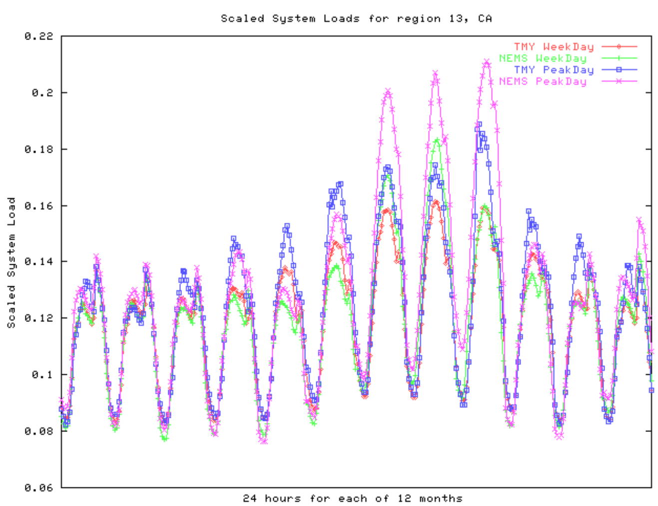
U.S. Department of Energy
Energy Efficiency and Renewable Energy

Environmental Assessment and Utility Impact Analysis

Environmental Assessment and Utility Impact Analysis

Comparison of NEMS and TMY System Loads



- As with end-use loads, TMY weather removes extreme temperature swings in the system loads – Results in TMY loads being less peaky than NEMS loads, which are based on an actual weather year
- Because TMY system and end-use loads are more coincident, NEMS loads were replaced with TMY loads

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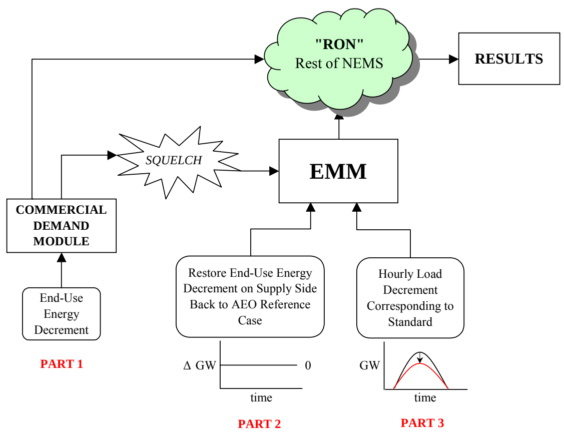
U.S. Department of Energy
Energy Efficiency and Renewable Energy

Environmental Assessment and Utility Impact Analysis

Environmental Assessment and Utility Impact Analysis
Double Decrement Approach using NEMS

- **Approach ensures that system loads are decremented appropriately**



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U.S. Department of Energy
Energy Efficiency and Renewable Energy

Environmental Assessment: Results

Environmental Assessment Results
Example: Commercial Unitary Air Conditioners and Heat Pumps

NEMS-BT Results							Difference from AEO2005 Reference with TMY System Load[4]									
	2000	**2005**	**2010**	**2015**	**2020**	**2025**		**2000**	**2005**	**2010**	**2015**	**2020**	**2025**	**2030**	**2035**	**2037**
AEO2005 Reference Case with TMY System Load														Extrapolation		
CO_2 (Mt/a)[1]	2283.0	2372.0	2624.0	2800.0	3024.0	3312.0										
NOx (kt/a)[2,3]	4681.1	3338.4	3637.8	3737.6	3810.2	3900.9										
Trial Standard Level 1																
CO_2 (Mt/a)	2283.0	2372.0	2624.0	2799.1	3022.3	3309.6	CO_2 (Mt/a)	0.0	0.0	0.0	-0.9	-1.7	-2.4	-2.4	-2.4	-2.4
NOx (kt/a)	4681.1	3338.4	3637.8	3737.1	3809.9	3900.3	NOx (kt/a)	0.0	0.0	0.0	-0.5	-0.3	-0.6	-0.6	-0.6	-0.6
Trial Standard Level 2																
CO_2 (Mt/a)	2283.0	2372.0	2624.0	2798.2	3020.6	3307.4	CO_2 (Mt/a)	0.0	0.0	0.0	-1.8	-3.4	-4.6	-4.6	-4.6	-4.6
NOx (kt/a)	4681.1	3338.4	3637.8	3736.6	3809.7	3900.0	NOx (kt/a)	0.0	0.0	0.0	-1.0	-0.5	-0.9	-0.9	-0.9	-0.9
Trial Standard Level 3																
CO_2 (Mt/a)	2283.0	2372.0	2624.0	2797.2	3018.8	3305.1	CO_2 (Mt/a)	0.0	0.0	0.0	-2.8	-5.2	-6.9	-6.9	-6.9	-6.9
NOx (kt/a)	4681.1	3338.4	3637.8	3736.1	3809.4	3899.6	NOx (kt/a)	0.0	0.0	0.0	-1.5	-0.8	-1.3	-1.3	-1.3	-1.3
Trial Standard Level 4																
CO_2 (Mt/a)	2283.0	2372.0	2624.0	2796.2	3017.0	3303.7	CO_2 (Mt/a)	0.0	0.0	0.0	-3.8	-7.0	-8.3	-8.3	-8.3	-8.3
NOx (kt/a)	4681.1	3338.4	3637.8	3735.7	3808.8	3899.2	NOx (kt/a)	0.0	0.0	0.0	-1.9	-1.4	-1.7	-1.7	-1.7	-1.7

[1] Comparable to Table A18 of AEO2005: Electric Power
[2] Comparable to Table A8 of AEO2005: Emissions
[3] All results in metric tons (t), equivalent to 1.1 short tons
[4] Negative values correspond to emission reductions

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Utility Impact Analysis Results

Example: Commercial Unitary Air Conditioners and Heat Pumps

Proposel Standard Level Forecast

NEMS-BT Results:

	2000	2005	2010	2015	2020	2025
Commercial Sector Energy Consumption						
Electricity Sales (TWh)	1,159	1,262	1,466	1,646	1,848	2,081
Natural Gas (EJ)	3.43	3.33	3.68	3.89	4.14	4.40
Other (EJ)	0.99	0.99	1.10	1.15	1.20	1.27
Natural Gas (Quads)	3.25	3.16	3.49	3.69	3.92	4.17
Other (Quads)	0.94	0.94	1.04	1.09	1.14	1.20
Total U.S. Electric Generation						
Coal (TWh)	1,967	2,073	2,235	2,318	2,524	2,898
Gas (TWh)	601	679	912	1,160	1,344	1,382
Petroleum (TWh)	111	119	124	132	140	147
Nuclear (TWh)	754	796	813	826	830	830
Renewables (TWh)	355	409	436	443	464	495
Total (TWh)	3,788	4,076	4,520	4,878	5,302	5,752
Installed Generating Capacity						
Coal (GW)	314.7	314.5	314.2	319.9	346.6	397.9
Other Fossil (GW)	283.0	442.5	451.6	450.7	505.4	545.2
Nuclear (GW)	98.3	99.7	100.6	102.2	102.7	102.7
Renewables (GW)	93.1	100.2	102.1	103.1	107.6	113.9
Total (GW)	789.1	956.9	968.5	975.9	1,062.3	1,159.6

Difference from AEO2005 Ref with TMY System Load

							Extrapolation	
	2000	2005	2010	2015	2020	2025	2030	2035
Commercial Sector Energy Consumption								
Electricity Sales (TWh)	0.0	0.0	-0.9	-5.8	-10.4	-12.8	-13.3	-13.2
Natural Gas (EJ)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Other (EJ)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Natural Gas (Quads)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Other (Quads)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total U.S. Electric Generation								
Coal (TWh)	0.0	0.0	-0.1	-2.0	-7.6	-9.7	-9.7	-9.7
Gas (TWh)	0.0	0.1	-0.9	-3.5	-2.5	-2.9	-2.9	-2.9
Petroleum (TWh)	0.0	0.0	-0.1	-0.3	-0.3	0.0	0.0	0.0
Nuclear (TWh)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Renewables (TWh)	0.0	0.1	-0.1	-0.2	-0.6	-1.1	-1.1	-1.1
Total (TWh)	0.0	0.2	-1.2	-6.0	-11.0	-13.7	-13.7	-13.7
Installed Generating Capacity								
Coal (GW)	0.0	0.0	0.0	-0.2	-1.0	-1.3	-1.3	-1.3
Other Fossil (GW)	0.0	0.0	0.0	-1.7	-3.2	-4.2	-4.2	-4.2
Nuclear (GW)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Renewables (GW)	0.0	0.0	0.0	0.0	-0.2	-0.3	-0.3	-0.3
Total (GW)	0.0	0.0	0.0	-1.9	-4.4	-5.9	-5.9	-5.9

Employment Impact Analysis

- **METHOD**
  - Use the IMBUILD (Impact of Building Energy Efficiency Programs) tool, a buildings-sector version of the IMPLAN national input-output model
  - Take change in equipment and energy expenditures from the National Impact Analysis (National Energy Savings (NES) spreadsheet)
  - Take direct employment impacts from the Manufacturer Impact Analysis
- **INPUT**
  - National appliance cost increases due to potential standards
  - National energy cost savings due to standards
  - National repair and maintenance cost increases (or savings) due to standards
  - National energy savings due to standards
- **OUTPUT**
  - Change in employment by sector as a consequence of new standards

Employment Impact Analysis – IMBUILD

- **Developed by Pacific Northwest National Laboratory**
- **Estimates the employment and income effects of building energy technologies, such as more efficient appliances**
- **Uses a 35-sector model of the national economy**
  - Provides overall estimates of the change in national output for each input-output sector
  - Applies estimates of employment and wage income per dollar of economic output for each sector and calculates impacts on national employment and wage income
- **Shows employment impacts specifically due to:**
  - Increased investment and spending on more efficient appliances in the manufacturing sector
  - Redirected consumer spending made possible by appliance energy savings
  - Decreased utility sector investment and redirection of funds to other sectors of economy

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Regulatory Impact Analysis

- **Method**
  - Identify non-regulatory alternatives
  - Conduct literature search to assess the impact that the non-regulatory alternatives have on consumer purchase decisions
  - Establish methodologies for modeling policy alternatives
  - Modify NES spreadsheet model to consider scenarios
- **Output**
  - National Energy Savings and Net Present Value of non-regulatory alternatives

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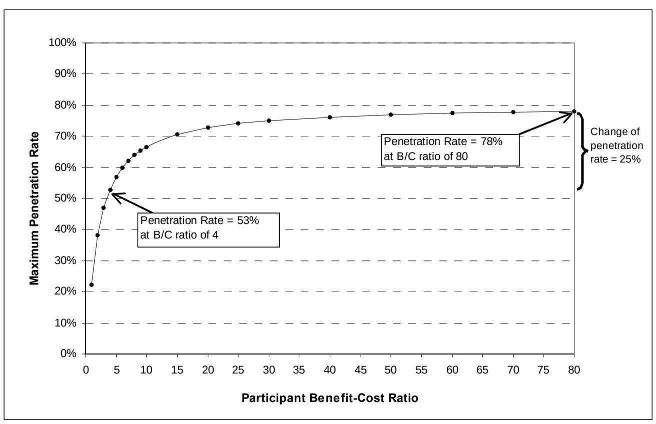
Non-regulatory Alternatives to Mandatory Standards

- **No new regulatory action**
- **Consumer rebates**
- **Consumer tax credits**
- **Manufacturer tax credits**
- **Voluntary efficiency targets**
- **Bulk government procurement**
- **Early replacement**

Regulator Impact Analysis – Consumer Rebates

- **Implementation Curves used to assess impact of Consumer Rebates**



- Benefit/Cost ratios determine consumer participation rates (i.e., increase of consumers purchasing more efficient appliances)
- Example shows increased participation rate for commercial unitary air conditioner consumers assuming rebates cover 95% of incremental price of more efficient equipment

Source: Rufo, M. and F. Coito, California's Secret Energy Surplus: the Potential for Energy Efficiency, 2002. Xenergy, Inc., Oakland, CA.

Estimated Participation Rates due other Non-regulatory Alternatives to Mandatory Standards

- **Consumer tax credits**
  - 60% of the impact of rebates based on regulatory impact analysis for refrigerators
- **Manufacturer tax credits**
  - Half the impact of consumer tax credits assuming no announcement effect
  - Based on analysis of residential customer equipment purchase decisions by K. Train, *Customer Decision Study: Analysis of Residential Customer Equipment Purchase Decisions*, 1994. Prepared for Southern California Edison by Cambridge Systematics, Pacific Consulting Services, The Technology Applications Group, and California Survey Research Services.
- **Voluntary efficiency targets**
  - Increased participation rates based on estimates from current Energy Star programs
- **Bulk government procurement**
  - Increased participation rates based on impact of Federal Energy Management Programs (FEMP)
- **Early replacement**
  - Based on analysis of the potential of early replacement programs conducted for DOE

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Ron Lewis

DOE		Jim Raba	Mohammed Khan	Antonio Bouza	Bryan Berringer	
LBNL	Group Management			James E. McMahon Group Leader		
	Product Managers and Engineers	Gregory Rosenquist Assistant Group Leader (Air-Conditioning and Refrigeration & HID Lamps)	Alex Lekov / James Lutz (Space-Heating and Water-Heating)	John Stoops (Distribution Transformers and Misc. Electrical)	Steve Meyers (Motors)	Peter Biermayer (Consumer Electronics, Clothes/Dish-Washers)
	Engineering Support	Barbara Atkinson Andrea Denver	Victor Franco Gabrielle Woing-Parodi	Consultant Stanley Merritt		
	Economists and Economic Analysts	Larry Dale Katie Coughlin Richard White Diane Fisher	Michael McNeil Camilla Whitehead Xiaomin Liu	Stuart Chaitkin Maithili Iyer Robert Van Buskirk	Utility/Environmental (NEMS) Chris Marnay Kristina LaCommare Etan Gumerman	
	Rulemaking Support	LBNL Washington Laura Van Wie McGrory	Steve Meyers	Diana Morris	Karen Olson	
	Computer Support	Terry Chan	Peter Chan	Chris Bolduc	Girish Ghatikar	

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Staff Resources

- **Distribution Transformers**
  - FY 2001-2004 funding and staff levels reflect effort to complete ANOPR

	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	Total
Key Personnel (person-months)						
Jim McMahon, PI	0.0	0.0	0.0	0.0	0.5	0.5
John Stoops, Project Manager	0.0	0.0	0.0	0.0	3.0	3.0
Robert Van Buskirk, Analyst	0.0	0.0	0.0	0.0	0.7	0.7
Maithili Iyer, Analyst	0.0	0.0	0.0	0.0	0.5	0.5
Stuart Chaitkin, Analyst	0.0	0.0	0.0	0.0	2.0	2.0
Larry Dale, Analyst	0.8	0.8	0.8	0.8	0.8	4.2
Peter Chan, Analyst	0.0	0.0	0.0	0.0	0.7	0.7
Laura Van Wie McGrory, Analyst	0.0	0.0	0.0	0.0	0.9	0.9
Kristina LaCommare, Analyst	0.8	0.8	0.8	0.8	0.8	4.2
Karen Olson, Analyst	0.0	0.0	0.0	0.0	0.4	0.4
Terry Chan, Analyst	0.0	0.0	0.0	0.0	0.6	0.6
Diana Morris, Admin. Support	0.0	0.0	0.0	0.0	0.9	0.9
Total (person-months)	**1.7**	**1.7**	**1.7**	**1.7**	**11.9**	**18.6**

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Staff Resources

- **Residential Furnaces and Boilers**
  - FY 2001-2004 funding and staff levels reflect effort to complete ANOPR

	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	Total
Key Personnel (person-months)						
Jim McMahon, PI	0.0	0.0	0.0	0.0	0.5	0.5
Alex Lekov, Project Manager	0.0	0.0	0.0	0.0	2.9	2.9
Jim Lutz, Analyst	0.0	0.0	0.0	0.0	0.5	0.5
Peter Chan, Analyst	0.0	0.0	0.0	0.0	0.7	0.7
Larry Dale, Analyst	0.8	0.8	0.8	0.8	0.8	4.2
Laura Van Wie McGrory, Analyst	0.0	0.0	0.0	0.0	0.9	0.9
Kristina LaCommare, Analyst	0.8	0.8	0.8	0.8	0.8	3.8
Steve Meyers, Analyst	0.0	0.0	0.0	0.0	0.5	0.5
Terry Chan, Analyst	0.0	0.0	0.0	0.0	0.6	0.6
Diana Morris, Admin. Support	0.0	0.0	0.0	0.0	0.9	0.9
Total (person-months)	**1.6**	**1.6**	**1.6**	**1.6**	**9.2**	**15.5**

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U.S. Department of Energy
Energy Efficiency and Renewable Energy

Accomplishments and Status

- **Distribution Transformers**
  - Framework Document – November 1, 2000
  - ANOPR Internet Webcast – August 10, 2004
  - ANOPR and TSD published July 29, 2004
  - ANOPR Public Meeting – September 28, 2004
  - Regulatory Agenda calls for NOPR TSD to be completed September, 2005
  - Regulatory Agenda calls for NOPR to be published September, 2006
  - Regulatory Agenda calls for Final Rule to be published - September, 2007

- **Residential Furnaces and Boilers**
  - Framework Document - July 17, 2001
  - ANOPR Internet Webcast – August 17, 2004
  - ANOPR and TSD published July 29, 2004
  - ANOPR Public Meeting – September 29, 2004
  - Regulatory Agenda calls for TSD to be completed September, 2005
  - Regulatory Agenda calls for NOPR to be published September, 2006
  - Regulatory Agenda calls for Final Rule to be published - September, 2007

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U.S. Department of Energy
Energy Efficiency and Renewable Energy

DOE Primary Technical Products

- **Distribution Transformers**
  - U.S. Department of Energy-Office of Energy Efficiency and Renewable Energy, *Technical Support Document: Energy Efficiency Program for Commercial and Industrial Equipment: Electrical Distribution Transformers*, July, 2004. Washington, DC.
  - U.S. Department of Energy-Office of Energy Efficiency and Renewable Energy, ANOPR Analytical Spreadsheets, Life-Cycle Cost Calculations by Design Line, October, 2004. Washington, DC.

- **Residential Furnaces and Boilers**
  - U.S. Department of Energy-Office of Energy Efficiency and Renewable Energy, *Technical Support Document: Energy Efficiency Program for Consumer Products: Energy Conservation Standards for Residential Furnaces and Boilers*, September, 2004. Washington, DC.
  - U.S. Department of Energy-Office of Energy Efficiency and Renewable Energy, Residential Furnaces and Boilers ANOPR Analytical Tools, October, 2004. Washington, DC.

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Associated Publications

- Hamachi LaCommare, Kristian, E. Gumerman, C. Marnay, P. Chan, and K. Coughlin, *A New Approach for Modeling the Peak Utility Impact from a Proposed CUAC Standard*, 2004. Lawrence Berkeley National Laboratory. Report No. LBNL-55269.
- Wong-Parodi, Gabrielle, A. Lekov, Alex, L. Dale. *Natural Gas Prices Forecast Comparison-AEO vs. Natural Gas Markets*, 2005. Lawrence Berkeley National Laboratory. LBNL-55701.
- Webber, C.A., R.E. Brown, and J.G. Koomey, Savings Estimates for the ENERGY STAR Voluntary Labeling Program. *Energy Policy*, 2000. vol. 28, no. 15: pp. 1137-1150.
- Webber, C.A.., R.E. Brown, A. Mahajan, and J.G. Koomey, *Savings Estimates for the ENERGY STAR Voluntary Labeling Program: 2001 Status Report*, 2002, Lawrence Berkeley National Laboratory. Report No. LBNL-48496.
- U.S. Department of Energy, *Early Replacement of Appliances*, 1994. Unpublished report by James E. McMahon and J.P. Harris, Lawrence Berkeley National Laboratory.

Associated Publications (cont.)

- Koomey, J. G., Avoiding “The Big Mistake” in forecasting technology adoption. *Technological Forecasting & Social Change*, 2002. 69 (2002) 511–518.
- Lawrence Berkeley National Laboratory-End-Use Forecasting Group. *Analysis of Tax Credits for Efficient Equipment.* Berkeley, CA. (Last accessed May 10, 2005.) <http://enduse.lbl.gov/Projects/TaxCredits.html>
- Harris, J.,, “Energy-Efficient Purchasing by State and Local Government: Triggering a Landslide down the Slippery Slope to Market Transformation.” *In ACEEE 2004 Summer Study on Energy Efficiency in Buildings*, 2004. Asilomar, CA, August 22-27. American Council for an Energy-Efficient Economy. 6: pp. 190-205.
- Harris, J. and F. Johnson, “Potential Energy, Cost, and CO2 Savings from Energy- Efficient Government Purchase.” *In ACEEE 2000 Summer Study on Energy Efficiency in Buildings*. 2000. Asilomar, CA, August 20-25. American Council for an Energy-Efficient Economy. 4: pp. 147-166. LBNL Report No. LBNL-45439.

PEER REVIEWER EVALUATION FORM

U.S. Department of Energy
Building Technologies Program

Peer Reviewer Evaluation Form

Reviewer Name: Date of Review:

Project/Program:

Principal Investigator:

Instructions: Reviewers individually rate the project using five criteria, including an overall project rating, and add supporting comments for each. The rating scale for each is composed of integer values from one to ten, with the ends of the scale representing seriously deficient and outstanding attributes, respectively. If more space is required for comment, please use the comment continuation sheet.

Some of the criteria consist of two distinct, identified elements to the criterion. While these elements are not rated separately, it is important to consider them separately to insure that all aspects of the criterion are distinctly considered and evaluated. If you feel that there is a distinct difference in rating between two elements within a single criterion, please explain those differences in your supporting comments. You can even assign numerical ratings to each of the elements in your comments. However, please combine the two disparate ratings together to form a single numerical rating for the criterion.

C1. Approach

Reviewers assess the inputs to the project, including an assessment of:

a) Quality of Technical Approach – the rigor of the technical approach (work elements, procedures and methods, etc.) and the appropriateness of the approach to achieving the project objectives with the available funding. Covers both the technical approach and how well the approach has been executed at the task level.

b) Quality of Project Team -- the composition and quality of the resources engaged, including people and facilities. Considered are the depth and relevance of experience of individual team members and the balance of appropriate skills of the overall team.

Rating Scale:

SCORE	LEVEL	QUALITY OR PERFORMANCE CHARACTERISTICS
9 - 10	Outstanding	Project is designed with an expert and innovative approach with exceptional execution by an outstanding team
7 – 8	Good	A skillful approach with highly effective execution by a capable, balanced team of experienced investigators
5 – 6	Average	A reasonable approach and appropriate execution with room for improvement by a good team that lacks some skills
3 - 4	Fair	An approach with a missing element or an out-of-date approach with some gaps in execution by a rather weak team
1 - 2	Poor	An approach with major weaknesses and poor execution by a team with serious shortcomings

Circle the appropriate number for your rating.

Approach: 1 2 3 4 5 6 7 8 9 10

Very low quality **Very high quality**

Supporting Comments:

C2. Accomplishments

Reviewers assess the overall progress (as measured by internal milestones) and the quality, volume and probable effectiveness of the deliverables and external outputs from the project, as outlined below:

a) Technical Progress – progress as measured by programmatic performance indicators (such as successful completion of analyses) in accordance with the project's technical approach.

b) Quality – the quality of primary products from the project in terms of their technical rigor, clarity and appropriateness for the intended audience. Reviewers also assess the fidelity of the products to the technical approach and their impact on achieving the project's overall objectives.

Rating Scale:

SCORE	LEVEL	QUALITY OR PERFORMANCE CHARACTERISTICS
9 - 10	Outstanding	Project exceeds scheduled milestones, attains exceptional tangible achievements and produces high-quality products well-targeted to key customers and having a major impact on attaining objectives.
7 – 8	Good	Project meets all scheduled milestones, attains important achievements and produces high-quality products targeting key customers and having significant impact.
5 – 6	Average	Project mostly meets schedules, makes some modest achievements and produces products with some weaknesses for targeting key customers and having significant impact.
3 – 4	Fair	Project somewhat behind schedule with a limited number of achievements and products with a questionable impact.
1 – 2	Poor	Project seriously behind schedule with few achievements and low-quality products with serious shortcomings and low impact.

Accomplishments: Circle the appropriate number for your rating.

1 2 3 4 5 6 7 8 9 10

Supporting Comments:

C3. Productivity

Productivity is assessed by looking at the accomplishments and the value of the accomplishments compared to costs, in relation to the overall project objectives.

Rating Scale:

SCORE	LEVEL	QUALITY OR PERFORMANCE CHARACTERISTICS
9 - 10	Outstanding	Exceptional output and value relative to the total cost and risks involved.
7 – 8	Good	Well above average output and value compared to total cost and risk.
5 – 6	Average	Reasonable level of output; about the expected norm for a project of this total cost and risk.
3 - 4	Fair	Somewhat lower output than typical for the costs; value is relatively low compared to the total costs.
1 - 2	Poor	Accomplishments and outputs seriously deficient compared to costs and risk.

Productivity: Circle the appropriate number for your rating.

1 2 3 4 5 6 7 8 9 10

Low productivity **High productivity**

Supporting Comments:

C4. Relevance and Adequacy

Reviewers assess the importance of achieving the project's objectives in terms of actual or potential contribution to the broader BT program mission, goals, or strategy and to society. Reviewers also evaluate the relevance to which the set of activities addresses known (or anticipated) and significant technical barriers, and adequacy of the analytical tools (i.e., models, spreadsheets, etc.) being used that are likely to contribute to lowering one or more of those barriers. For these projects, reviewers consider the degree to which the project supports the proposed energy efficiency standards and/or how much critical information it adds to the knowledge base.

Rating Scale:

SCORE	LEVEL	QUALITY OR PERFORMANCE CHARACTERISTICS
9 – 10	Outstanding	Objectives are of central importance to larger program goals and achieving the objectives will very significantly reduce major technical barriers with a high probability.
7 – 8	Good	Objectives are highly important to overall goals and achieving the objectives will likely result in significant and measurable reductions in technical barriers.
5 – 6	Average	Objectives are of general importance and will possibly contribute somewhat to achieving goals and reducing barriers.
3 - 4	Fair	Objectives weakly support the overall program goals and are unlikely (or highly uncertain) to significantly reduce important technical barriers.
1 - 2	Poor	Objectives are largely peripheral or disconnected from overall program goals and are unlikely to measurably reduce any technical barriers.

Relevance:

Circle the appropriate number for your rating.

1 2 3 4 5 6 7 8 9 10

Not Very Relevant **Very Relevant**

Supporting Comments:

C5. Overall Assessment

Please provide your general overall rating of the project, followed by comments. In addition, please separately highlight any factors or considerations which have not been adequately covered by the 4 previous criteria.

Rating Scale:

SCORE	LEVEL	QUALITY OR PERFORMANCE CHARACTERISTICS
9 - 10	Outstanding	A world-class project in nearly all respects.
7 – 8	Good	A strong project deserving of priority continuation.
5 – 6	Average	A project deserving of continuation, but having some shortcomings that should be addressed by the PI.
3 - 4	Fair	A weak project or one with some significant deficiencies requiring management attention.
1 - 2	Poor	A project with serious deficiencies which warrants careful re-evaluation.

Overall Rating

Circle the appropriate number for your rating.

1 2 3 4 5 6 7 8 9 10

Very Poor **Average** **Outstanding**

Supporting Comments:

Areas of useful comment include (a) overall strengths and weaknesses, (b) areas of analyses that could be revised, deleted, or added, (c) new areas or directions that could be added, and (d) changes that may have occurred in the rulemaking context that might alter the planned targets or goals.

PEER REVIEW AGENDA JUNE 28 & 29, 2005

Agenda for U.S. Department of Energy
Appliance Standards Peer Review
DOE Forrestal Building, Room GH-019
June 28 – 29, 2005

DAY ONE – TUESDAY, JUNE 28, 2005

8:30 – 9:00 AM **Introduction**

9:00 – 5:00 PM **Appliance Standards Project Reviews**

9:00 – 11:00 PM Michael Rivest – Navigant Consulting Inc.
Topic: Screening and Engineering Analyses
9:00 – 10:00 Oral Presentation
10:00 – 10:30 Q&A
10:30 – 11:00 Evaluation Forms

11:00 – 11:20 AM **Peer Reviewer Discussion**

11:20 – 12:20 PM Lunch

12:20 – 2:20 PM Michael Rivest - Navigant Consulting Inc.
Topic: Markups for Appliance Price Determination
James McMahon – Lawrence Berkeley National Laboratory
Topic: Life-Cycle Cost and Payback Period Analysis/Life-Cycle Cost Consumer Sub-group Analysis
12:20 – 1:20 Oral Presentation
1:20 – 1:50 Q&A
1:50 – 2:20 Evaluation Forms

2:20 – 2:35 PM Break

2:35 – 4:35 PM James McMahon - Lawrence Berkeley National Laboratory
Topic: Shipments Analysis and National Impact Analysis
2:35 – 3:35 Oral Presentation
3:35 – 4:05 Q&A
4:05 – 4:35 Evaluation Forms

4:35– 5:00 PM **Peer Reviewer Discussion**

DAY TWO – WEDNESDAY, JUNE 29, 2005

8:30 – 8:40 AM **Introduction (Recap of Day 1 activities)**

8:40 – 1:00 PM **Appliance Standards Project Reviews**

8:40 – 10:40 AM	Michael Rivest – Navigant Consulting Inc. Topic: Manufacturer Impact Analysis (MIA) 8:40 – 9:40 Oral Presentation 9:40 – 10:10 Q&A 10:10 – 10:40 Evaluation Forms
10:40 – 11:00 AM	Break
11:00 – 1:00 PM	James McMahon - Lawrence Berkeley National Laboratory Topic: Utility Impact Analysis, Environmental Assessment, Employment Impact Analysis, and Regulatory Impact Analysis 11:00 – 12:00 Oral Presentation 12:00 – 12:30 Q&A 12:30 – 1:00 Evaluation Forms

1:00 – 1:30 PM **Complete Evaluation of BT Peer Review Process**

1:30 PM **Adjournment**

CONFLICT OF INTEREST AGREEMENT

You have been nominated by DOE/EERE to serve as a Peer Reviewer for the Appliance Standards element of the Building Technologies (BT) Program. Your participation in this review will be greatly appreciated. However, it is possible that your personal affiliations and involvement in certain activities could pose a conflict of interest or create the appearance that you lack impartiality in your evaluations and recommendations for this peer review. In order to assess if you have a real or perceived conflict of interest in regard to the appliance standards projects that will be evaluated in this peer review, please complete the information below. This information will be reviewed by the peer review leader in order to identify potential conflicts of interest and assure that you are not placed in a position to review and evaluate projects that may present the appearance of partiality.

SECTION 1: AFFILIATIONS, ACTIVITIES AND PROGRAM INVOLVEMENT

At the end of this section you will be asked to list those specific Appliance Standards projects or areas where a conflict or appearance of conflict could exist and explain the nature of that conflict. A conflict in one area does not necessarily exclude you from serving as a reviewer in another area. The review leader may call you for more information.

Affiliations or activities that could potentially lead to conflicts of interest may include the following:

a: Work or known future work for parties that could be affected by your judgments on projects or program developments that you have been asked to review.

b: Any personal benefit you (or your employer, spouse or dependent child) might gain in a direct or predictable way from the developments of the program/projects you have been asked to review.

c: Any previous involvement you have had with the program/projects you have been asked to review, such as having participated in a solicitation to the program area that was subsequently not funded, or having a professor, student, or collaborator relationship with the program or its research staff.

d: Any financial interest held by you (or your employer, spouse or dependent child) that could be affected by your participation in this matter.

e: Any financial relationship you have or have had with DOE/EERE such as research grants or cooperative agreements.

Personal involvement with the research program or with other DOE program areas.

Yes **No**

I previously was involved in research funded by this program area _____ _____

I participated in a solicitation from this program area _____ _____

I reviewed this program area previously. _____ _____

I am a former professor or student of a Principal Investigator _____ _____

I previously collaborated with the Principal Investigator in a research activity in program/project area. _____ _____

Appliance Standards Projects	Nature of conflict of interest

(continue on another sheet if necessary)

SECTION 2: CONFLICT OF INTEREST AGREEMENT

CONFLICT OF INTEREST AGREEMENT

This agreement must be completed by individuals prior to their participation in EERE peer reviews. Please contact __John Ryan__ to discuss any potential conflict of interest issues at your earliest convenience, but no later than June 20th.

I have reviewed the information contained on this form and to the best of my knowledge I have disclosed any actual or potential conflicts of interest that I may have in regard to the program/projects that I have been nominated to evaluate. In addition, prior to my participation as a peer reviewer, I agree to disclose any actual or perceived conflicts of interest as soon as I am aware of the conflict.

_______________________________ ______________________

Signature Date

____

Printed Name

NONDISCLOUSRE AGREEMENT

U.S. Department of Energy
Building Technologies Program

Peer Review Nondisclosure Agreement

I agree to use the information revealed during review of the

Appliance Standards Subprogram

only for Department of Energy (DOE) assessment purposes and to treat the information which may be confidential in nature in confidence.

If in the course of this subprogram review, I do acquire or have access to any information, data, or material which is business confidential, proprietary, or otherwise privileged, and is so indicated in writing, I agree that such information will not be divulged to any person or any organization or utilized for my own private purposes or in any manner whatsoever, other than in the performance of this subprogram review:

1. without the prior written permission of the disclosing party or the contracting officer for the work being evaluated, or

2. until such information, data, or material is first publicly disseminated by the DOE or its contractor or grantee performing the work, or

3. is or becomes known to the public from a source other than me, or

4. is already known to me or my employer as shown by prior records, whichever event shall first occur.

____
(Signature)

____
(Name)
Printed or Typed

____
(Date)

GUIDELINES FOR PEER REVIEWERS

Guidelines for Peer Reviewers

You are asked to provide intellectually fair and disinterested expert evaluation of research, demonstration and deployment sponsored by the Office of Building Technologies (BT). This evaluation will be considered by DOE managers in setting program priorities and will be used by program managers and researchers to improve their programs and projects.

Scope of the Review: It is important to recognize that the evaluation is for individual projects against objective criteria. The evaluation is not a comparative evaluation of one project against another. The peer review is also not intended to evaluate the overall program portfolio, the set of projects taken together, or the overall level of funding allocated by BT to the program area. However, you should consider the adequacy of the funding in relation to the objectives for an individual project because the contractor has the responsibility to negotiate, plan and execute the project to meet the objectives within the available funding. You will have the opportunity at the end of the review session to comment on the overall program portfolio, suggest other avenues of research, discuss the balance between available funding and objectives and address other, higher-level management issues which are stimulated by the project-level evaluations. BT values these higher-level perspectives, even though they are not the primary purpose of the peer review.

The BT peer review covers all projects currently or recently in the BT portfolio. Therefore, the projects being reviewed will be at various stages of completion. Reviewers are asked to examine the entire project life cycle — both completed work and planned future work – regardless of the present degree of project completion. For this activity, a project is defined as an executable element of a program, normally with its own discrete beginning, end, and specific outcome.

Project Mission and Goals: It is important that you understand the mission of this program and the general goals. Your review should be conducted with the program mission and relevant goals in mind.

- ***EERE Mission*****:** Strengthen America's energy security, environmental quality, and economic vitality through public-private partnerships that: enhance energy efficiency and productivity; bring clean, reliable, and affordable energy production and delivery technologies to the marketplace; and make a difference in the everyday lives of Americans by enhancing their energy choices and their quality of life.

- ***BT Program Goal*****:** By 2025, the Building Technologies Program will create technologies and design approaches that enable the construction of net-zero energy buildings at low incremental cost.

Evaluation Criteria: Your evaluation of the projects will be based on the following criteria:

- **Approach –** This criterion is primarily used to measure the inputs to the project. Reviewers assess the quality of the technical approach, people, facilities and other resources involved. Reviewers also assess technical quality in the execution of the technical approach.

- **Accomplishments -** Accomplishments are a measure of progress and outputs. Reviewers assess the overall progress (as measured by internal milestones) and the quality, volume and probable effectiveness of the deliverables and external outputs from the project.

- **Productivity -** Productivity is a relative measure of the progress and outputs. Reviewers assess productivity by comparing the technical progress, accomplishments and the value of outputs to the costs, in relation to the overall project objectives and the degree of risk.

- **Relevance** – Relevance is measure of importance. Reviewers assess the project's contribution to the broader program mission, goals, or strategy, and to society. Reviewers also assess the extent to which the activities address significant technical or market barriers and the degree of innovation and advancement relative to existing technology or practice. For more basic research projects, reviewers assess the project's contribution to advancing the underlying science and adding to the knowledge base.

- **Overall Assessment -** Reviewers provide a general, overall rating of the project along with overarching or summary comments.

Basis for Evaluation:
You should base your evaluation primarily on the information provided by the Principal Investigator (PI) and information and insights developed as a part of this peer review process. This includes:

- **PI-provided Project Descriptions**
- **Reports and other materials provided**
- **PI presentations at the peer review session**
- **Q&A dialogue with PIs and discussions among reviewers**

You can use information which you have obtained independently through outside reading or experience. However, it is important for you to bring such information to the attention of the review panel and explain it during the session to insure that all reviewers are working with a common set of information.

Reviewer Expectations:

The volume of reports and other materials provided to reviewers can be rather extensive. We try to limit the volume of this material and still provide appropriate technical detail. However, for some projects, the PI only provides rather detailed and lengthy material. (And for some other projects, the supporting material is very limited.) We expect reviewers to fully and carefully read all of the 10-page Project Descriptions prior to the review meeting. In addition, we expect reviewers to selectively review some of the technical reports and other material, concentrating on areas most closely aligned with their expertise, where Project Descriptions need amplification or where particular issues arise. DOE expects the peer reviewers to devote at least one full day (and as much as two full days, depending on the number of projects) for reviewing the material, in advance of the peer review meeting.

Evaluation Procedure:

Project Ratings and Comments: Your evaluation of each project is expressed by a numerical rating and commentary. Please discriminate among the projects by clearly rewarding excellent work with high ratings and giving lower ratings to work you feel is of lower quality. When completing the evaluation form for a project, please try your best to provide a rating for each criterion. If you do not give a rating for a criterion, please give a short explanation why. It is absolutely vital for you to go well beyond the rating – your commentary should provide a defensible rationale for the rating and a basis for further action, if needed. Ratings, by themselves, do not provide a basis for informed and defensible action to improve or reward projects.

Consensus & Attribution: There is no attempt to achieve a consensus in the review. We encourage panel members to discuss the relative merits of each project and there may be some narrowing of viewpoints as a result. Nevertheless, we want to preserve each reviewer's individual evaluation of each project. Differences of opinion among reviewers are normal and provide valuable insights, as long as the reviewers' comments provide reasons for the differences.

Your individual comments are anonymous – your name will be listed as a reviewer but attribution of your comments will not be made outside the department. Furthermore, peer review administrators will consider a request by the panel for anonymity inside the department - to avoid attribution of comments to either the project/program managers or to DOE/BT management.

Procedure for Recording Comments: Evaluation forms are provided in both electronic and paper form. Each reviewer is expected to fill out the evaluation form for each project at the conclusion of each project presentation to capture immediate impressions. Additional time will be available at the end of the review meeting to revise or add comments. It is most efficient to record comments electronically, in real time. Notebook PC computers can be made available at the review session, if arranged in advance, for those reviewers who do not plan to bring their own. Electronic files for recording comments will be provided in various media forms for uploading into PCs at the beginning of the meeting. **At the conclusion of the peer review meeting, we ask that reviewers do not depart from the meeting without handing in their full comments.**

Important comments or perspectives sometimes occur to reviewers in the immediate aftermath of the formal review meeting. Reviewers can send in additional comments up to five days after the meeting, and they will be treated as a supplement to the comments developed during the session.

Session Procedure: All peer reviewers on a panel participate in person at a formal peer review meeting. The meeting starts with a short presentation by the DOE peer review leader on the peer review process. The DOE project manager for the research program may also provide a summary of the program for context.

Following opening remarks, the meeting consists of a series of project-specific sessions, each organized as follows:

- An oral presentation by the Principal Investigator (PI)
- A question-and-answer period during which reviewers interact with the PI or other project personnel who are present
- A period for the reviewers to fill out the evaluation forms for the project and interact among themselves, without the PI being present.

The DOE project manager for the project and the DOE peer review leader will be present in the room during the meeting. After the first project presentation, the panel is given the opportunity to ask the DOE project manager and peer review leader questions about the peer review process, such as how to interpret the evaluation criteria.

Process Improvement: At the end of the meeting, the peer reviewers are asked to fill out a questionnaire on the overall peer review process itself. Your responses are invaluable in the continuous improvement of the BT peer review procedure. Each program review and each panel meeting incorporate the lessons learned and reviewer recommendations from the preceding program reviews.